ENGINEERING NEWS
AND
AMERICAN RAILWAY JOURNAL.

Vol. XXXVII., No. 23.

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THE PHILADELPHIA & READING SUBWAY for the depression of the tracks of this railway company on Pennsylvania Avenue, in Philadelphia, is progressing rapidly. Actual work was commenced on Oct. 1, 1896, under the appropriation of $6,000,000 for this purpose and the many contracts let in May of the same year. The temporary track system and temporary freight sheds on Hamilton and Callowhill streets are nearly completed; the north abutment wall of the tunnel is being pushed and the skewbacks for the arch are set at a number of points. The work east of the tunnel, or east of 22d St., consists of the laying of the retaining walls to hold the sides of the open subway and the reconstruction and underpinning of buildings on the line. These retaining walls are well advanced on the south side of the avenue, as far east as 16th St. The earth core for the depressed freight yard is being removed by steam shovel work. The details of this subway were described and illustrated in Engineering News of April 16, 1896.

TWO ELABORATE EXPRESS TRAINS have been put on by the Chicago, Burlington & Quincy R. R. to run between Chicago and St. Paul and Minneapolis as the "Limited Express" service. Each train consists of six cars, as follows: A combination baggage, smoking and buffet car, a regular sleeping car, a compartment sleeping car, a chair car, a day car and a dining car. The combination car is 72 ft. long exclusive of the platforms, and has a smoking room 32 ft. long, with chairs, a lounge, card table, bookcase, writing desk and buffet. The sleeping car is 70 ft. long, with a main saloon 50 ft. long, having 16 sections. The compartment car is 69 ft. 10 ins. long (76 ft. over platforms) and has seven staterooms and two drawing rooms, each of which has toilet accommodation and a closet. The corridor is on one side of the car for half its length, and then on the other side. The chair car is 60 ft. long and has seating capacity for 56 persons. The dining car has four tables, accommodating four persons each, and four tables accommodating two persons each. The trains are lighted by electricity, by means of storage batteries under each car, these batteries being charged at each end of the run. They are also fitted with the Pintsch gas lighting equipment. All the cars are, of course, fitted for steam heat. The cars were built by the Pullman Palace Car Co., of Chicago, and are all fitted with vestibules the full width of the cars, and are mounted on four-wheel trucks having 38-in. Allen wheels, with paper centers. The dining car has six-wheel trucks, with brakes on all wheels.

AMERICAN STEAM ENGINES FOR AUSTRALIA is a recent achievement of that enterprising concern, the E. P. Allis Co., of Milwaukee, Wis. The firm has received an order for four cross-compound engines with cylinders 26 and 50 ins. diameter and 48 ins. stroke, direct-coupled to the dynamos, which will furnish current for the street railways of Sydney, New South Wales. As these tramway lines are owned and operated by the Government, the victory for engines of American manufacture is especially remarkable.

GONDOLA COAL CARS OF 60,000 lbs. capacity (100 cars) are being built by the Mount Vernon Car Mfg. Co., of Mount Vernon Ill., for the Titusville, Evansville & St. Louis Consolidated R. R., and we are indebted to Mr. George T. Jarvis, Receiver and General Manager of the railway, for the following list of dimensions, etc.:

	Ft.	Ins.
Length over couplers	37	6
Length over end sills	34	2
Length inside body	32	5½
Width over side sills	8	6
Width inside body	8	1½
Height, rail to bottom of hopper	3	3
Height, rail to top of sills	4	3
Height, rail to top of body	7	11
Number of sills	6	
Size of sills.....four 5½ × 13½ ins.; two, 4 × 8 ins.		
Number of hoppers	4	
Number of doors	8	
Size of openings of hopper doors..4 ft. 10 ins. × 2 ft. 9 ins.		
Journals of axles	4¼ × 8 ins.	
Wheels, diameter	33 ins.	
Wheel base of each truck	5 ft. 1 in.	
Distance c. to c. of trucks	24 ft. 2 ins.	
Carrying capacity	60,000 lbs.	
Weight, including trucks	30,000 lbs.	
Approximate cost	$364.80	
Couplers	Shickle, Harrison & Howard	
Brake beams	Wooden trussed	
Trucks	Diamond	
Wheels	Cast iron	

THE CONSTRUCTION OF FILTER BEDS for the water-works of Albany, N. Y., in accordance with the general plans outlined in our issues of Feb. 18 and May 6, 1897, will be started soon, the plans having been approved by the common council, legislative authority to issue $500,000 of bonds having been secured and Mr. Allen Hazen, Assoc. M. Am. Soc. C. E., St. Paul Building, New York, having been appointed as engineer to carry out the work in accordance with his preliminary report. The estimated cost of the plant is about $435,000.

MUNICIPAL OWNERSHIP OF WATER-WORKS AT Watertown, Mass., has been decided upon by a popular vote of 535 to 17. The population of the town in 1890 was 7,073. It is stated that the purchase of the works by the town is preparatory to entering the Metropolitan Water District. This may have had something to do with the practical unanimity of the vote, although changes from public to private ownership of water-works in Massachusetts have been many of late, as was shown in our issue of April 29, at least 20 such changes having been made since the beginning of 1890.

AN ARTESIAN WELL, 1,000 ft. deep, 8 ins. diameter, has been sunk at Hoffman Island, in New York Harbor, 1¼ miles from shore, by Elisha Gregory, contractor, of New York. It has been tested by pumping and yields 30 to 40 gallons per minute of fresh water. This is said to be the only successful deep well in the harbor that is getting fresh water from below the salt water. A well was sunk by other parties at Ellis Island to a depth of 1,300 ft., but this is claimed to have been a failure.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was a collision on June 7 on the Chicago, St. Paul, Minneapolis & Omaha R. R., near Hudson Junction, Wis. The trains in collision were a way freight and a work train, the latter backing eastward and the former moving west. Five men were killed. The accident is said to have been due to the engineer and conductor of the work train taking the east-bound track instead of the west-bound, to which their orders entitled them.——On the same date an Illinois Central express train struck a protruding rail on a push car which was being loaded by a section gang. The rail penetrated the front of a coach and seriously injured a passenger.

A FREIGHT ELEVATOR CAR in the New York post office fell four stories on June 7, seriously injuring the six men who were in it. The elevator was put in in 1891 by the McAdams & Cartwright Elevator Co., of New York city. It was a steam operated elevator, and the car was hoisted by two ⅝-in. 19-wire cables, which run from the car to the top of the shaft, thence over pulleys and down to a 4-ft. winding drum in the basement. The winding drum was driven through a gear wheel and pinion by a shaft on which was mounted a pulley about 5 ft. diameter and 12-in. face, driven by a 11-in. double belt from the pulley on the engine shaft. The engine was an ordinary double-cylinder hoisting engine. The 11-in. belt was tightened by a heavy idler wheel resting upon it, the idler being held in position on the belt by a forked lever, the inner end of which was pivoted on the engine frame, the other end being free to move up and down with the fluctuations of the belt, as it was held against the belt only by gravity.

At the time of the accident the car, which itself weighed about 1,500 lbs., was loaded with 1,120 lbs. of cement, and six passengers, the total load, exclusive of the car, being probably about 2,000 lbs. The load which it was rated to carry was 3,000 lbs. When just starting from the second floor, after taking on two passengers, the car suddenly reversed its motion and ran rapidly to the bottom of the shaft. The steel cables, which were afterwards found to have broken at a point about a foot from their point of attachment to the drum, ran over the sheaves at the head of the shaft and fell down on the car, crushing in its roof and inflicting further injuries on the passengers in the car. The location of the break in the ropes indicates that this break was an effect and not the cause of the accident. The most probable cause seems to be a combination of a somewhat careless handling of the elevator and a defect in its design, which made such careless handling especially dangerous. It will be noted in the description given above that the belt operating the drum is tightened by an idler wheel, acted on by gravity only. A sudden starting of the engine while the car is heavily loaded causes a surge of the belt which throws the idler entirely out of contact with the belt. While the belt is in this manner made loose there is nothing to prevent the belt slipping, which allows the load to run down. The heavy load having started to run acquires momentum, the belt continues to surge, and the idler is ineffective. A ribbon brake is attached to the drum, which may be operated by the elevator man, but he probably lost his presence of mind and failed to pull the rope when the car began to run down. The safety catches would not operate, because they are designed to operate only when the rope breaks, and there is no safety governor on the elevator which will throw the catches when the car runs too fast.

The elevator and its machinery, of which two are in the New York post office, is about the cheapest kind of steam hoisting apparatus built. It has all the defects of spur-geared belt-driven elevators, with the addition of a belt tightener, which is essentially a dangerous contrivance. It is a disgrace to the government that it should use such cheap and unsafe machinery in its public buildings.

THE REMOVAL BY DYNAMITE of the hull of the steamer "Ailsa," sunk in 41 to 50 ft. of water on Feb. 29, 1896, off Fort Hamilton, in New York Bay, has been ordered by the government. The "Ailsa" is sunk in 8 ft. of mud, hard on one side and soft on the other, and attempts were made to raise her by the use of wooden pontoons. The attempt failed, for various reasons, after 30 of these cask-like air reservoirs had been attached to her by chains. The Merritt & Chapman Wrecking Co. will now proceed to cut the hull into sections by explosives and to lift the detached pieces of the wreck by a derrick of 150 tons capacity. Owing to the strong prevailing tides, the removal of the wreck will probably consume three months, as the divers can only work from 3 to 5 hours in any one day.

THE RIGHTS OF TUNNEL OWNERS to veins of ore discovered within the tunnel is affirmed by a recent decision of the U. S. Supreme Court at Washington, D. C. The case was that of Campbell vs. Eliet, decided along with the Rico-Aspen tunnel suit. The vein of mineral-bearing rock, which did not appear on the surface, was found in the tunnel 594 ft. from the face. The owners posted a notice of this discovery at the mouth of the mine, claiming 750 ft. of this vein on each side of the tunnel line, and filed a location certificate for this location and expended $100 per year on the lode. Eleven years after another party, with full knowledge of the tunnel claim, made a location upon it at the surface; made a discovery cut, and having marked out the surface boundaries, applied for a patent. Upon this application the suit was brought by the tunnel owners. Justice Brewer now decides that the discovery of the vein in the tunnel, worked according to the statutes, gives a right to the possession of the vein for the same length as if discovered on the surface; and that a location on the surface is not essential to a continuance of that right.

THE FRANKLIN INSTITUTE OF PHILADELPHIA has organized from among its members a Mining and Metallurgical Section, with 62 members at the start and Mr. Benjamin Smith Lyman as its President. This section proposes to promote all branches of mineral industry by holding meetings for the reading of papers and the discussion of pertinent matter; by the publication of its proceedings and by the formation of a museum of economic minerals, mineral products and objects illustrating the working of mines and the utilization of minerals. Stated meetings are held in the hall of the Institute, and a number of papers have already been presented. Mr. Wm. C. Henderson is the Secretary of this section.

A CANADIAN TRANSATLANTIC LINE of fast steamers is to be started in 1898, the Dominion government having entered into a contract with Paterson, Tait & Co., of Newcastle, England, to operate such a service, with steamers capable of making 20 knots per hour. The company will receive annual subsidies of $500,000 from the Dominion government and $250,000 from the British government.

THE MADISON HILL INCLINE; P., C., C. & ST. L. RY.

By Edw. Grafstrom.*

Since the publication of the description of the heavy tank engine which the Pittsburg, Cincinnati, Chicago & St. Louis Ry. put in service last year, on the Madison Hill incline (Eng. News, Nov. 26, 1896,) a large number of inquiries had been received concerning this incline. Although

Fig. 1.—Deep Cut on the Madison Hill Incline; P., C., C. & St. L. Ry.

famous at the time of its construction, it appeared to have been completely forgotten by most engineers, and to many its existence was quite a revelation. The writer has, therefore, prepared the following historical sketch on the origin and development of engineering on the Madison Hill, from notes collected from time to time during his connection with the company. So far as the writer knows, only three articles upon this incline have ever appeared in engineering literature. These were as follows: (1) "London Engineering," in 1868; (2) A contribution by the late Max J. Becker, M. Am. Soc. C. E., to the "Transactions of the American Society of Civil Engineers," in 1878; (3) A paper read three years ago before the Institution of Civil Engineers, entitled, "Mountain Railways." None of these papers, however, contained much more than constructive details.

The town of Madison, Ind., is located 85 miles southeast of Indianapolis, where the Ohio River cuts a deep furrow in the high table land of Indiana and Kentucky. It does not, apparently, differ much from other river towns of its size, and the passengers on the daily packets between Cincinnati and Louisville pass it by without a second thought. But from a railway engineering point of view it has an interesting history in connection with the so-called inclined plane, which played an important part in the early developments of the state of Indiana.

Long before the trunk lines, which now, with their connections, traverse the state in every direction were even thought of, Madison and Vincennes were the only two cities of the young state. In those days, when river traffic was at its height and the Ohio River was the great channel of commerce, the wharf of Madison was the gateway of Indiana. The transportation route from the East and from Europe lay up the river from New Orleans, which at the beginning of the century was the great inlet for traders and travelers to the inland states and border territories. Later, however, the traffic from the Eastern states was largely diverted to a new route through Pennsylvania over the "Old Portage Road" and the Johnstown canal to Pittsburg, and down the Ohio River to Madison. The importance of Madison as a distributing point of manufactured goods from the East for the interior, and as a shipping point of raw material, farm produce and stock from the surrounding country, was readily understood by leading citizens of the times. Mr. Milton Stapp, of Madison, an influential legislator and politician of note, closely identified with the early history of Indiana, brought his energy to bear on the state assembly at Vincennes, then the capital, until that body took cognizance thereof by appointing a commission for the purpose of examining into and reporting upon the best means of facilitating the transportation of freight and travelers from the river port to the upper plateau, where the trails leading out across the great plains of the state began.

The problem before these pioneer engineers was to connect the upper level, sloping down almost to the water's edge, with the river bank, 450 ft. below. After a great deal of figuring and discussion the route was finally decided upon and surveyed in the summer of 1835 by Mr. John Woodburn, the head of the commission. The plan adopted was to build a road 1½ miles in length, with a grade of 5.9%, which undoubtedly was the best that could be done without too much deviation from the general direction. Imbued with the spirit of the time and actuated by Mr. Milton Stapp and Governor Noah Noble, the state assembly in the meantime desided to venture upon a railway from North Madison, the upper terminus of this grade, and extending along the wagon trail to Vernon, a prominent settlement of cattlemen, a day's journey from Madison. Through the untiring efforts of Mr. Stapp and the commissioner, Mr. Woodburn, work upon this, the first railway in Indiana and one of the first in the United States, was thus actually commenced in the summer of 1837, between North Madison and Graham Creek. The grading and ballasting were finished the same year and the superstructure was begun the following May.

The work upon the incline, for which contracts had been let at the same time, had been begun on Sept. 16, 1837, but on account of the difficulties met with, it was not completed until 1841. This work was divided into three sections. Flint & Stough had the first section nearest the river, Joseph Hendricks the middle, and James Giddings the upper section. The exact length was 7,012 ft., with a total elevation of 413 ft., or 311 ft. per mile. A portion of the incline was cut through solid rock over 100 ft. in depth, and two embankments were made, nearly 100 ft. in height each. The cut is illustrated in Fig. 1, and the lower entrance to the same in Fig. 2, which also gives a fair idea of the grade.

June 10, 1838, marked a new epoch in Indiana, for on that day the first consignment of rails brought into the state was unloaded from the steamer "General Haynes" at the wharf of Madison. It consisted of 500 tons, and came from Liverpool, via New Orleans. The rail was of the old T-pattern, and most of it was laid on the section above North Madison as far as to Graham Creek. One of these rails, laid during that summer remained in the track, rendering continuous service until 1881, when it was eventually replaced with a new steel rail. The roadbed was laid with two lines of 10×10-in. mud-sills, or longitudinals. Cedar ties, 6 × 8 ins., were pinned with locust pins to the mud-sills, and upon these the chairs which carried the T-shaped rails were spiked with hand-made spikes.

On this track light four-wheel cars, similar to the push cars now used by section men, were pulled up one at a time by means of a string of mules. At first they carried only freight, and the passengers were still for some years brought up to the top by a hack line in a roundabout way. The cars were let down the incline with the aid of powerful lever-brakes, the heavy wooden brake shoes of which were prevented from igniting by frequent applications of water carried for that purpose in leather buckets on the cars. The first cars were designed by Mr. Emmor Kimber, who as early as 1831 had obtained a patent, bearing the signature of Andrew Jackson, President of the United States, which covered some novel points in the construction of cars adapted to and particularly intended for the service on this grade.

Although the incline was not completed until 1841, the railway north of North Madison was opened for traffic as far as Griffiths, 14 miles, in the spring of 1839. The state thus having built and owning the road, entrusted, nevertheless, its operation to a private firm, "the Branhams & Co.'s Transportation Line," which had previously maintained stage coach and steamer lines extensively through southern Indiana. This company leased the road on the condition of paying to the state 60% of the net revenue derived from the property. In 1841, however, the lease was not renewed, and the state had to take charge of the operation, the road having in the meantime been completed to Vernon. For a still further extension of the road the legislature that year had recourse to the "first internal improvement bond issue," through the sale of which the necessary funds for construction and equipment were obtained.

FIG. 2.—VIEW ON THE MADISON HILL INCLINE.

At this juncture the first regularly incorporated railway company in this part of the country was formed, styled the Madison & Indianapolis R. R. Co., under the state laws of Indiana, enacted for

*Chief Draftsman of the Motive Power Department; P., C., C. & St. L. Ry., Columbus, O.

the purpose of enabling this particular concern to relieve the state of the care and trouble of operating a railway. Accordingly, this company took possession of the property the following year, assuming all the obligations of the state. The work staked out by the state commission was pushed on until finally, in 1847, Indianapolis was reached, that city being then a growing settlement far inferior to Madison, but already selected as the future seat of the state government. The entrance of the railway into Indianapolis signaled the advancement of a new era for the town, and the city charter was granted simultaneously with the formal opening of the road that year.

One of the first improvements the new railway management inaugurated in the service of the Madison incline was to supplant the mules with a rack locomotive, the "M. G. Bright," afterwards called the "Indiana." The rack-rail for this engine was cut out of iron and was laid upon 3-in. oak planks, mortised into the sills and held in place with oak wedges. Each section of the rack was 18 ins. long and had 10 cogs. The locomotive was placed in service in November, 1848.

Fig. 3 gives an idea of the appearance of the engine dismantled. It was designed by Mr. Andrew Cathcart, Master Mechanic of the new company, and built by the Baldwin Locomotive Works in 1847. The eight driving wheels, 42 ins. in diameter, were actuated by inclined cylinders, 15½ × 20 ins. Another pair of cylinders, 17 × 18 ins., placed vertically over the boiler, had connecting rods to a crank shaft under the boiler. This shaft carried a single pinion in the centre, which engaged with another cog-wheel twice its size, on a second shaft behind the first. The cogs on this wheel engaged in the rack rail. The small horizontal cylinder on top of the boiler operated a pair of cranks, the horizontal arms of which supported hangers, which were connected with the journals of the crank shaft. By means of this cylinder the crank shaft could be pressed down while on the incline, or raised up while the engine was working on the level. The weight of the engine was about 50,000 lbs. The wood and water for the boiler were carried on a four-wheel truck behind. In the spherically formed crown-sheet can be traced the origin of the present dome.

Another similar engine, the "John Brough," was built by the Baldwins from the same design in 1850, to meet the rapidly growing demands of the traffic, as well as to be used as a relay. Although these locomotives had the aid of the adhesive weight on the driving wheels to assist the cog-wheels during the ascent, as is the practice in the Abt system of rack roads, now used on a number of steep inclines, they did not have the double cog-wheel with staggered teeth, nor any of the other improvements of that admirable system. Frequently when an engine was working on the incline, it would happen that the cog-wheel was accidentally raised high enough to disengage the cogs, and before it again could be forced down in gear the train would be thundering down the incline at a terrific speed, for there were no effective safety appliances of any kind and the day of the air brake had not yet dawned. The citizens of Madison grew so familiar with the peculiar clattering noise made by a runaway engine racing down the rack that they knew it instantly and turned out in force to assist the victims at the foot of the hill, where the trains always jumped the track on such occasions, if they had succeeded in sticking to it so far. These disasters, coupled with the absence of any provision for engaging the cog-wheel in the rack when approaching the beginning of the grade at the top or bottom, were a source of continuous trouble.

The engines seemed to fill their purpose, however, and earn money for the company, in spite of the frequent fatalities with, it is to be presumed, damage suits following close. No wonder that the company could afford it, when, for instance, the freight charges on a barrel of salt from Madison to Vernon, a distance of 20 miles, was 80 cts., or as much as the price of the barrel is to-day.

It might not be amiss to add a few personal notes bearing upon the early management and operation of this pioneer railroad. The first president of the company was Mr. Nathan B. Powell.

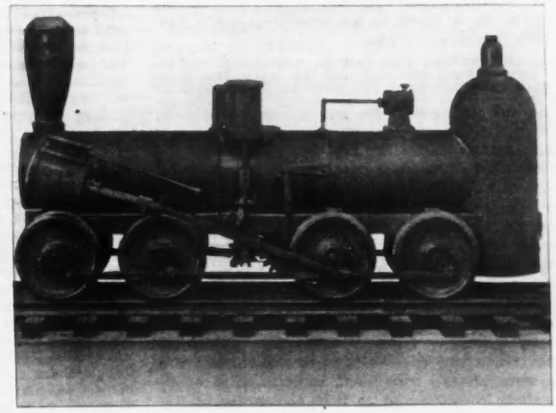

FIG. 3.—ORIGINAL RACK RAIL LOCOMOTIVE FOR THE MADISON HILL INCLINE, 1847 (DISMANTLED).

Mr. R. J. Elvin, from whose personal reminiscences part of the material for this history has been obtained, was the accountant, clerk and book-keeper; Mr. Samuel Thomas had charge of the engines, and Mr. David C. Branham of the car repairs. Mr. John Lodge was the principal conductor, who had charge of all trains (few as they were), and generally went with them over the road, accompanied by Mr. Wm. H. Branham, who attended to the baggage and freight. Tickets were not sold to passengers, but a way-bill (similar to those now used for freight trains) was made out for each train and bore the name and destination of each traveler.

As the business of the company increased and the trains grew more numerous, the inconvenience of the rack railway became more apparent, and the company's engineers began to look around for other means of reaching Madison. Several new routes were surveyed, and the one finally decided upon consisted of following a ravine up from the river bank to a point 1¼ miles west of North Madison, tunneling through the sandstone hills for about a mile to another ravine, gradually rising to the upper level, and then swinging round to connect with the present track a short distanec below Griffith's station. The work on this route was commenced and carried on rapidly, notwithstanding that the machinery for tunneling was of the simplest and crudest kind. The tunnel was finally finished, but in the meantime many events had occurred which had materially changed the conditions of the company, and a general business depression had set in, cutting down the revenue of the road considerably. The old road was then deemed good enough under the altered conditions, and the work of grading the tunnel and the new route was stopped, never to be resumed. The tunnel is still there, caved in and partly filled up, a page in the history of the road cut in stone. But the rack road was nevertheless obsolete and its day of usefulness had passed.

After 20 years of service the Cathcart locomotives on the incline were finally succeeded by another, designed by Mr. Reuben Wells, and built by him at the company's shops at Jeffersonville, Ind., to which place a connecting line had been secured in 1858. This locomotive, named after its designer, was placed in service in July, 1868. It is illustrated in Fig. 4. As will be noticed, Mr. Wells boldly abandoned the use of the rack and depended entirely on the adhesive weight of the engine, which up to that time had been considered impractical on so steep a grade. In point of fact, while the engine was in process of construction the American Society of Civil Engineers, as well as other honorable bodies pronounced themselves of the opinion that the engine could not pull its own weight up the incline. When it had been put in service and had practically demonstrated its ability to handle even a greater load than the rack engines, it consequently created quite a mild sensation in railway engineering circles. London "Engineering" would not be convinced of the performance of the engine until it had sent a special representative to Madison to verify the reports.

This remarkable locomotive was the heaviest ever built up to that time, and in fact, for several years afterwards. It is still in useful condition and preserved in its original shape, except that in 1886 the rear pair of driving wheels was removed, principally on account of difficulty in passing over the curves in the yards at Madison. The water tanks were also abbreviated 5 ft. at that time, and to compensate for this a saddle tank was added on top of the boiler.

The engine weighs in its present form 57 tons in working order, with full tanks and fuel supply.

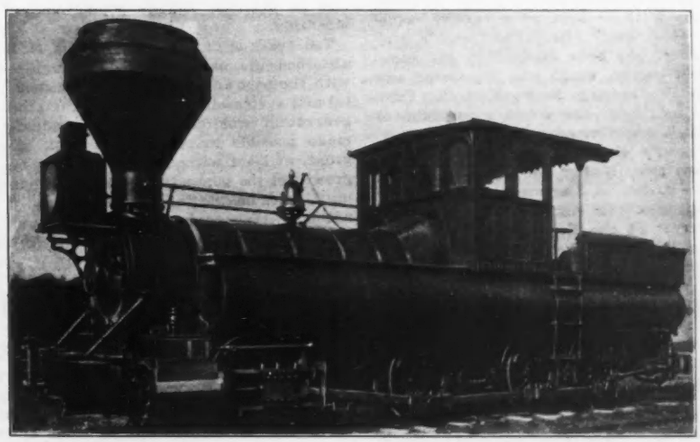

FIG. 4.—FIRST ADHESION LOCOMOTIVE FOR THE MADISON HILL INCLINE; 1868.

It has 8 coupled driving wheels, 44 ins. in diameter, with a total wheel base of 16 ft. The cylinders are 20 × 24 ins., the diameter of the boiler is 56 ins., and there are 201 tubes, 2 ins. in diameter. The boiler pressure at present is 125 lbs., although at one time it was 140 lbs. The engine has in later years been equipped with air brakes, but in descending the incline it depends upon the retarding influence of the pistons in the steam cylinders, which, when the engine drifts down the hill (with the steam shut off and the links in

the reverse position), act as air pumps forcing the air in front of the piston through a pipe connecting one end of the cylinder with the other. The passage of air through this pipe is regulated by a cock operated from the cab. During part of the stroke a great deal of air is sucked into the cylinders from the smoke box, but as the engine is a wood burner, no cinders or grit pass into the cylinders to the injury of the same, as would be the case had coal been used for fuel.

On account of the success of this locomotive one of the old rack engines, the "M. G. Bright," was rebuilt in 1871 on the same principle, although in smaller proportions, weighing only 44¾ tons.

The earliest accurate record at hand of the performance of Mr. Wells' engine was established in April, 1875, by Mr. M. J. Becker, M. Am. Soc. C. E., then Chief Engineer of the Pennsylvania Lines, by which system the old railway had been absorbed on Jan. 1, 1873. During Mr. Becker's trial the engine pushed up eight cars of the light construction then in vogue, the total weight of the train, including the engine being 210.2 tons. This compares well with the figures noted by Mr. A. M. Wellington in his work on "The Economic Theory of Railway Location," which gives a gross load of 203 tons for 52 tons adhesive engine weight on a 6% grade. The present hauling power of the engine is, however, considerably less, being only 184 gross tons, for which performance about ½ cord of wood is consumed. The degeneration is principally caused by the reduced boiler pressure and by lost motion in the well-worn machinery. The speed of the engine

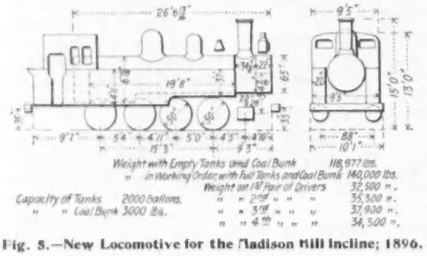
Weight with Empty Tanks and Coal Bunk 118,977 lbs.
" in Working Order with full Tanks and Coal Bunk 140,000 lbs.
Weight on 1st Pair of Drivers 32,500 "
" " 2nd " " " 36,300 "
" " 3rd " " " 37,900 "
" " 4th " " " 34,300 "
Capacity of Tanks 2000 Gallons.
" " Coal Bunk 3000 lbs.

Fig. 5.—New Locomotive for the Madison Hill Incline; 1896.

at the trial referred to was 6 miles per hour. The engine alone was run up the hill on the same date at the rate of 14.6 miles per hour.

With the beginning of last year the Pennsylvania Lines placed a new engine in service on the incline to take the place of the "Reuben Wells," which is to be kept as a reserve, while the old "M. G. Bright," after almost half a century's existence, has been doomed to the scrap pile. The new engine, which was illustrated and described in Engineering News, Nov. 26, 1896, was constructed under the direct supervision of Mr. S. P. Bush, Superintendent of Motive Power, in the company's shops, at Columbus, O.; by Mr. B. Fitzpatrick, Master Mechanic, from the designs of the writer. A diagram giving the principal dimensions of this engine is shown in Fig. 5. The boiler is of the Belpaire type and carries 150 lbs. pressure. The engine is equipped with the American driver brake, in addition to a powerful screw hand-brake. For controlling the speed of the engine while descending the incline, a modification of the "Le Chatelier" system of water brake is used, similar to that in service on the Pike's Peak Ry. (Abt rack system), the Colorado Midland Ry. and other Western mountain roads. But, instead of closing off the communication from the smoke box to the cylinders by means of a plug valve in the exhaust column, a simple yet effective device, suggested by Mr. Reuben Wells (at present Superintendent of the Rogers Locomotive Co.), is used. This consists of directing a steam jet upwards in the exhaust column, while at the same time a valve at the side of the smoke box is opened to admit clean air into the exhaust passages to the cylinders. The steam jet creates an upward draft in the exhaust column, sufficient to prevent the rushing down of the air from the smoke box.

The engine was put in regular service on the incline on Jan. 1, 1896. No official trial of its hauling ability has as yet been made and it is not expected that it will be undertaken until this spring, after the engine has been in continuous service for a year or more. The indications are, however, that the expectations of the officials will be fully met. On the first day a train consisting of three loaded and four empty freight cars, together with a passenger coach, was pushed up over rails which could not have been much worse for rain and sleet. The train weighed 157 tons, which, with the engine weight, made a total of 227 tons.

In regard to the performance of the engine, Mr. E. E. Morris, Road Foreman of Engines on the Division, in a letter to headquarters dated Jan. 4, 1896, wrote as follows:

This afternoon we were able to make three trips on one tank of water and coal, and we expect that three coalings a day will do all the work that is necessary on the hill. In a few days we shall be able to take the old engine and its train up the hill without the slightest trouble.

The history of the old Madison incline and the railway of which it is a part parallels the history of the town of Madison closely. When the railway was constructed the town had a population of about 2,000. As the road was pushed on towards the center of the state the town kept growing, until in 1847, when the connection to Indianapolis was opened up, the population of Madison had reached 6,000. Then began the palmy days of the railway. Instead of running "mixed" trains, regular scheduled passenger trains, two a day each way, were put on, and the cars were always well filled, sometimes to overcrowding. People began to take advantage of the railway to reach the river, where they could take the boats in either direction. The freight business increased in the same proportion as the passengers. In point of fact, Madison began to enjoy the distinction of being the second largest stock market in the country. The revenue of the road ran up from a few thousand dollars a year to more than half a million dollars in 1852, and the population of the town had increased to over 8,000, not including the large percentage of transient residents.

Then came the period of competition. Indianapolis had been connected by rail with the east, and even the traffic from the river was competed for by two newcomers, the Lawrenceburg R. R. (now a part of the Cleveland, Cincinnati, Chicago & St. Louis Ry.), and the New Albany R. R. (now a part of the Baltimore & Ohio R. R. system). The decadence of the old Madison road began, and eventually it had to be sold at sheriff's sale in 1862. The town of Madison likewise began to lose its activity, and its population fell off considerably.

Ten years later the Pennsylvania R. R. interest absorbed the old road, and through-connections with the east and west were established. By careful and systematic management the process of degeneration was checked, and gradually it was made possible to operate the road, if not at a profit, at least without loss. A slow but healthy growth of the population of Madison has followed, until, after having fallen off almost 2,000, it again not only reached its former maximum, but increased beyond that, until it now is in the neighborhood of 12,000.

THE MINERAL PRODUCTION OF THE UNITED STATES IN 1895 AND 1896.

We are indebted to the courtesy of our contemporary "The Engineering and Mining Journal," for the privilege of reproducing the accompanying table, which is a summary of the statistics that are given in the fifth annual issue of its well-known work "The Mineral Industry." The table will be found very useful for reference.

It appears from the figures which our contemporary has collected that notwithstanding the "hard times" of 1896, presidential election, silver fright, low prices and all, the value of the mineral and metal production of the United States last year was greater than in any year on record.

Making deductions from the totals given by the table for cases where the same product is given twice, as iron ore and pig iron, coal used for coke making, etc., our contemporary states that the total value of minerals and metals produced in the United States in 1896 was $706,015,411, as compared with $682,065,118 in 1895; the change shown being an increase of $23,950,293, or 3.5% for the year.

We extract from the "Mining Journal's" column the following brief notes respecting the production of materials of most interest to our readers:

Aluminum.—The production of this metal remains in the hands of a single company, though recent patent decisions make it probable that the monopoly may be broken before long. The plant at Niagara Falls has made it possible to cheapen production and lower prices. An enlargement of the works has been required to meet the demand.

Copper.—The production for 1896 reached the large total ever reported, 467,822,923 lbs., equal to 208,850 long tons, or 212,201 metric tons. Over half of the production was sent abroad, the shipments to foreign countries amounting to no less than 125,605 long tons, or 59.2% of the output. Had it not been for an extraordinary foreign demand the production of copper must have been very much curtailed, instead of showing, as it did, an increase of 81,369,123 lbs., or 21.1%. The foreign demand also kept up the average price, which was 10.88 cts. per lb. for Lake copper in New York, against 10.76 cts. in 1895. This price is probably about half a cent above the general average for the metal, when the large sales of electrolytic and casting copper are considered.

Gold.—Activity in the older mining regions of California and other States and the increased production of Cripple Creek and of some minor districts in Colorado, with improvements in several other States and in the territory of Alaska, carried the gold production up to 58,660,727, showing an increase of $11,830,527 over 1895. The districts which attracted most attention during the year were Cripple Creek in Colorado; the new Randsburg Mining District in Southern California; the Mercur District in Utah; the De la Mar Mines in Nevada, and the mines of Alaska. In the latter there were many reports of new mines and a number of men went to the Yukon placers, but their success has been varied.

Iron.—The iron trade showed a reaction from the activity of 1895, and there was a decrease in the production of pig iron of 823,181 tons, or 8.8%. There was a corresponding reduction in steel and finished iron in nearly all forms. The average price showed also a decrease. The year was one of extremely low prices in iron and steel; in fact their range was regarded as the lowest possible until 1897 opened. The most notable fact of the year was the beginning of an export trade in iron and steel, which promises to reach large proportions.

Lead.—The production of lead in 1896 in the United States was 174,792 short tons (158,271 metric tons), an increase over 1895 of 17,938 short tons, or 11.4%. This was made in spite of the closing of the Leadville mines in Colorado nearly half the year by the great strike.

Silver.—The production of silver showed a large increase over the previous year, the total refined or obtained from our own ores having been 56,222,322 fine oz., or 9,891,087 oz. more than in 1895. In addition to this product there was obtained by our smelters and refiners from foreign ores and bullion—chiefly from Mexico and British Columbia—33,053,555 oz., making the total quantity of silver put into marketable form 89,275,877 oz.

Zinc.—The output of metallic zinc or spelter in 1896 was 77,637 short tons or 70,432 metric tons, and was less than that of 1895 by 4,221 short tons, or 5%. This decrease was divided among the different producing districts, and was the result chiefly of limited demand for the metal. Our producers are able to increase the supply largely, if a market can be found for it. New uses for the metal, especially for roofing, have been suggested and ought to be furnished.

Cement.—The cement producers reported in 1896 a decrease of 139,442 barrels in the production of natural hydraulic cement. This was more than made up, however, by an increase of 283,595 barrels in Portland cement. This would indicate a production slightly increased in 1896, and a growing demand for the manufactured or Portland cement.

Coal and Coke.—The total coal production in 1896, with a possible modification in the Ohio figures, was 187,373,477 short tons, showing a decrease of 1,922,167 tons, or 1%, as compared with 1895. The decline was wholly in anthracite, the output of which decreased 3,041,734 tons, or about 6%. In bituminous coal there was less change than might have been expected in a year of business depression and lessened industrial activity, a gain of 1,134,654 tons being noted. There was a drop in values exceeding the change in production, owing to the very low average price realized. Coal sold at the mines in many parts of the United States at lower prices in 1896 than had ever before been accepted. Heavy production and sharp competition in a year of comparatively light demand were responsible for this result. Unfortunately, there appears to be little prospect for relief for the coal operators. In such a condition the districts which produce at the lowest cost and are best situated in relation to the markets will certainly secure the trade and others must suffer.

Coke showed a total production of 10,357,000 short tons, a decrease of 2,136,464 tons, or 17.1%, from 1895. The coke trade is so dependent on the demand from the iron furnaces that its changes follow very closely those in iron

roduction. The only matter worthy of note is the beginning of a movement which may in time transfer the chief center of coke production from Western Pennsylvania to West Virginia. Some progress was made in 1896 in the introduction of by-product coke ovens.

Iron Ore.—The decrease of 1,338,000 tons corresponded nearly to that in pig-iron production. The stocks of ore on hand at the opening of the year were generally light.

Paints.—In mineral paints, chiefly the iron oxide paints, there was a considerable increase, the total in 1896 being 93,153 short tons. Of vermilion only 90 tons were reported. The production of white lead was large, reaching 90,668 tons in 1896, or 2,129 tons more than in 1895. Zinc white, on the other hand, decreased in production, the total of 16,799 tons reported being less than that for 1895 by 5,891 tons. It may be noted that most of the zinc white is made directly from ores, and not from metal like white lead.

Petroleum.—The production of crude petroleum was 61,396,394 barrels, or more than that of 1895 by 8,434,451 barrels. No new fields of importance were discovered during the year, but there was considerable extension of work in the West Virginia field. The value of the new oilfield in Tennessee is not yet determined.

Phosphates and Marls.—A heavy decrease in the production of phosphate rock is shown, due to the closing down of many of the South Carolina and Florida producers on account of low prices and light demand for export. The new phosphate fields in Tennessee promise well, but their production has not yet reached an important amount. The total output of phosphate rock in 1896 was 863,754 tons; of marl 155,000 tons.

Slate.—The total value of slate, roofing and manufactured, was $2,728,437, a small decrease from the preceding year, but less than was anticipated in a year when building was not active.

MINERAL PRODUCTION OF THE UNITED STATES IN 1895–6.

Compiled for THE MINERAL INDUSTRY, Vol. V.,

By Richard P. Rothwell, editor of the *Engineering and Mining Journal.*

Number.	Products.	Customary Measures.	1895. Quantity. Customary Measures.	1895. Quantity. Metric Tons.	1895. Value at Place of Production. Totals.	1895. Value at Place of Production. Per M Ton.	1896. Quantity. Customary Measures.	1896. Quantity. Metric Tons.	1896. Value at Place of Production. Totals.	1896. Value at Place of Production. Per M. Ton.
	NON-METALLIC.									
	Abrasives:									
1	Carborundum	Sh. T.	113	102	$67,800	$6.65	595	550	$365,612	$6.65
2	Corundum	Sh. T.	885	349	53,900	154 44	250	227	35,000	153.75
3	Emery	Sh. T.	1,700	1,543	119,000	77.17	1,550	1,406	108,500	77.17
4	Garnet	Sh. T.	877	795	39,465	49.65	2,842	2,578	96,628	37.48
5	Grindstones	Sh. T	36,389	33,004	290,378	8.79	31,301	28,396	294,398	10.36
6	Millstones				15,925				14,852	
7	Tripoli & inf. earth	Sh. T.	1,783	1,617	26,049	16.00	2,425	2,199	31,028	14.56
8	Whetstones				93,303				105,201	
9	Alum	Sh. T.	117,900	106,959	3,537,000	33.07	77,700	70,489	2,331,000	33.07
10	Antimony ore	Sh. T.	1,083	982	37,905	38.60	150	136	4,750	34.92
	Asbestos and talc:									
11	Asbestos	Sh. T.	664	602	11,837	19.66	716	650	12,670	19.49
12	Soapstone	Sh. T.	22,133	20,007	342,208	17.03	24,319	22,068	265,806	12.05
13	Talc, fibrous	Sh. T.	40,000	36,368	320,000	8.80	45,000	40,824	315,000	7.70
14	Asphalt	Sh. T.	25,525	23,156	170,500	7 36	20,500	19,926	66,900	3.36
15	Asphaltic limestone	Sh. T.	5,550	5,035	16,650	3.31	3,119	2,829	8,714	3.08
16	Bitumin's sandstone	Sh. T.	42,374	38,542	139,945	3.63	53,119	48,189	128,714	2.66
17	Barytes	Sh. T.	20,255	18,371	99,020	5.39	21,700	19,504	86,000	4.41
18	Bauxite	L. T.	18,800	19,100	56,400	2.90	17,056	17,360	68,384	3.93
19	Borax	Lbs.	13,500,356	6,126	742,850	*f* 12	15,238,014	6,921	702,900	*f* 11
20	Bromine	Lbs.	394,854	179	162,662	*f* 57	550,275	249	143,074	*f* 57
21	Cement, nat. hydraul.	Bbls *a*	7,094,053	1,047,006	4,597,285	4.39	7,454,611	1,014,423	4,353,377	4.29
22	Cement, Portland	Bbls *b*	749,059	135,879	1,430,089	10.52	1,082,654	187,365	1,710,151	9.12
23	Clay, refractory	Sh. T.	8,750,000	3,402,000	4,500,000	1.35	4,000,000	3,628,800	4,800,000	1.32
24	Clay, china	Sh. T.	80,910	48,035	278,431	9.22	29,418	26,688	217,551	8.15
25	Clay, common	Sh. T.			160,100,000				165,000,000	
26	Coal, anthracite	Sh. T.	51,897,297	47,081,308	80,250,652	1.71	48,855,563	44,321,768	88,105,337	1.98
27	Coal, bituminous (*h*)	Sh. T.	137,328,600	124,584,506	123,897,998	1.00	138,403,254	125,613,864	115,827,813	93
28	Coal, cannel	Sh. T.	69,747	63,274	191,804	3.08	54,660	49,587	146,488	2.95
29	Coke	Sh. T.	12,493,464	11,333,996	19,018,270	1.68	10,357,000	9,395,869	17,267,401	1.84
30	Cobalt oxide	Lbs.	6,400	*f* 2,903	8,640	*f* 30	12,925	*f* 5,817	16,672	*f* 28
31	Copperas	Sh. T.	14,118	12,805	69,846	5.45	11,170	10,133	52,662	5.19
32	Copper sulphate	Lbs.	45,000,000	20,412	1,750,000	85.73	48,732,840	21,605	1,949,313	90.22
33	Chrome ore	L. T.	1,553	1,578	16,795	10.64	702	718	7,775	10.90
34	Feldspar	L. T.	22,195	22,550	104,082	4.67	22,199	22,554	112,829	5.00
35	Fluorspar	Sh. T.	4,000	3,628	24,000	6.61	4,000	3,628	24,000	6.61
36	Gilsonite (*k*)	Sh. T.	1,150	1,043	34,500	32.12	1,700	1,542	54,500	35.34
37	Graphite, crystalline	Lbs.	377,450	172	17,286	*f* 50	405,006	184	18,225	9.90
38	Graphite, amorphous	Sh. T.	840	762	4,700	6.17	574	520	3,850	7.40
39	Gypsum	Sh. T.	298,572	270,864	974,219	3.59	231,049	210,152	739,799	3.52
40	Iron ore	L. T.	15,988,000	16,243,808	27,979,000	1.72	14,650,000	14,884,400	28,567,500	1.92
41	Lime	Bbls *c*	600,000,000	5,443,164	30,000,000		460,000,000	5,443,164	30,000,000	
42	Magnesite	Sh. T.	2,200	1,995	14,700	7.39	2,067	1,875	13,435	7.16
43	Manganese ore	L. T.	179,509	173,337	328,167	1.84	162,526	165,126	339,083	2.05
44	Mica, ground	Lbs.	740,000	335	31,956	95.40	877,000	398	37,711	94.75
45	Mica, sheet	Lbs.	6,200	3	6,400	*f* 2.13	8,000	4	8,405	*f* 2.31
46	Mineral wool	Sh. T.	6,989	6,340	74,962	11.36	5,953	5,400	61,714	11.43
47	Monazite	Lbs.	1,900,000	862	114,000	132 40	17,500	8	875	109.37
48	Natural gas				12,000,000				10,000,000	
49	Paints, mineral	Sh. T.	47,084	42,705	1,080,767	25.45	54,153	49,227	973,298	19.77
50	Paints, vermilion	Sh. T.	118	107	118,190	1105.00	96	87	94,677	1088.25
51	Paints, white lead	Sh. T.	92,939	84,314	8,768,656	104.00	95,068	86,246	7,802,267	90.46
52	Paints, zinc oxide	Sh. T.	22,690	20,498	1,588,300	77.43	16,799	15,240	1,259,925	82.67
53	Petroleum (crude)	Bbls *d*	52,961,943	7,215,996	47,624,913	6.60	61,396,394	8,364,631	56,963,157	6.81
54	Phosphate rock	L. T.	1,098,017	1,015,587	3,296,757	3.25	863,754	877,574	2,591,262	2.93
55	Marls	L. T.	217,700	221,183	587,790	2.67	155,000	157,480	418,500	2.65
56	Precious stones				250,000				200,000	
57	Pyrites	L. T.	107,731	109,088	342,587	3.14	117,782	119,666	297,853	2.49
58	Salt, evaporated	Bbls *e*	12,091,367	1,535,591	5,643,383	3.61	11,156,270	1,416,846	4,828,179	3.41
59	Salt, rock	Bbls *e*	2,184,549	277,443	828,954	2.98	2,198,303	279,184	711,919	2.55
60	Silica, sand & quartz	L. T.	523,640	532,018	553,128	1.04	720,399	732,925	1,076,698	1.46
61	Slate, roofing	Sq'es.	752,606	238,576	2,494,213	10.45	699,100	221,615	2,260,862	10.25
62	Slate, manufactures				392,877				467,575	
63	Soda, natural	Sh. T.	1,900	1,724	47,500	27.56	3,000	2,722	65,000	23.88
64	Soda, manufactured	M. T.		167,000	3,841,000	23.00		158,975	3,656,425	23.00
65	Stone, limestone (flux)	L. T.	4,723,154	4,798,724	1,889,262		4,311,563	4,380,548	1,724,625	
66	Stone, marble	Cu. ft			2,888,114				2,600,429	
67	Stone, onyx	Cu. ft	1,200	91	12,000	131.87	3,000	228	24,000	105.26
68	Stone, oölitic	Cu. ft	4,790,422	365,108	1,005,192	2.75	4,040,999	308,111	755,891	2.45
69	Other building stones				26,269,943				27,219,484	
70	Sulphur	L. T.	1,650	1,676	41,250	24.60	2,800	2,845	64,200	22.56
71	Est. prod. unspecified				5,000,000				5,000,000	
	Total non-metals				488,651,351				495,747,553	
	METALS.									
72	Aluminum	Lbs.	900,000	408	495,000	*f* .25	1,300,000	590	520,000	*f* .18
73	Antimony	Sh. T.	466	422	70,332	166.42	613	556	85,700	154.32
74	Copper (*m*)	Lbs.	386,453,850	175,294	40,616,300	231.70	467,822,978	212,201	49,729,582	234.35
75	Gold	Ozs. *f*	2,265,612	70,478	46,830,200	664.60	2,837,965	88,272	58,680,637	664.60
76	Iron, pig	L. T.	9,446,308	9,597,449	108,632,542	10 77	8,623,127	8,761,120	91,577,610	10.45
77	Lead, value at N. Y.	Sh. T.	136,854	142,298	10,132,768	71.20	174,792	158,271	10,381,843	65.59
78	Platinum	Ozs. *f*		*f* 4.66	2,250	482.83	200	*f* 6.21	2,800	450.89
79	Quicksilver	Flksg	33,978	1,179	1,313,589	1114.00	33,180	1,151	1,227,660	1066.60
80	Silver, comm'l value	Ozs. *f*	46,331,235	*f* 1,441,087	30,254,296	*f* 20.99	56,222,322	*f* 1,748,710	37,725,178	21.57
81	Zinc	Sh. T.	81,858	74,245	5,942,890	80.04	77,637	70,432	6,074,219	86.24
	Total metals				244,290,167				255,985,229	
	Grand totals									

(*a*) Barrels of 300 lbs.; (*b*) 400 lbs.; (*c*) 200 lbs.; (*d*) 42 gals.; (*e*) 280 lbs. (*f*) Troy ounces. (*g*) Flasks of 76½ lbs. (*h*) Bituminous coal includes brown coal and lignite. The anthracite production is the total for Pennsylvania, Arkansas, and Colorado. (*i*) Estimated. (*j*) Kilograms or per kilogram. (*k*) Including bitumen from Texas. (*m*) The value of the copper production is calculated at 0 25c. per lb. less than the average price of Lake copper at New York.

Abbreviations: Sh. T., short tons (2000 lbs.); L. T., long tons (2240 lbs.); M. T., metric tons (2204.5 lbs.); Sq'es, squares (100 sq. ft., lapped and laid).

CAUSES AND REMEDIES FOR THE PARTING OF RAILWAY FREIGHT TRAINS.*

At the 1896 convention at Saratoga, N. Y., one of the most fruitful of the topical discussions was on the subject of "break-in-twos" between trains, and their causes. It was clearly shown, at that time, that there was very widespread trouble all over the country from this cause, not only in connection with the old link and pin drawbars, but also to an alarming extent in connection with the M. C. B. type of coupler. As a result of the very general interest taken in the discussion, this committee was appointed to make an investigation and report, giving the members of the association the result of inquiries made as to the extent and cause of "break-in-twos" on roads all over the country. Circulars of inquiry were sent out to all representative members of the association, asking for a record to be kept in detail of all cases of trains parting for a period of about three months. Unfortunately, the labor involved in obtaining these data was so considerable that only 31 roads responded. From these replies the committee has to present to the association some facts and also some recommendations, which, if followed up, we think may produce beneficial results in reducing the present very excessive number of cases of trains parting.

During the discussion at the 1896 convention it was shown that the railways were menaced by a continuation of "break-in-two" evils which it had confidently been expected would be overcome by the introduction of the M. C. B. type of coupler. Figures were given at that time indicating that it was possible that this evil was being increased rather than diminished by the supposed improvement. Such a state of things would be truly alarming, and it is with pleasure that your committee can report that the M. C. B. coupler itself cannot be charged with the responsibility for increasing the danger of train operation.

Much has been said and written in the last few years about foundation brake rigging, and the need of greater care in its design and application. There is perhaps an equal, if not a greater, need for study in the improvement in design and application of draft rigging and of the M. C. B. couplers on our freight equipment. The data obtained from replies to our circular of inquiry, together with an extended observation at home and abroad on our railways, have convinced your committee that some radical steps must be taken to improve and maintain in proper shape the couplers, draft rigging and attachments on our cars.

A summary of the facts obtained from the 31 railway companies, representing 37,490 miles of track and 376,010 cars, shows in an average period of 105 days the alarmingly large total of 5,775 cases of trains parting, 103 of which were accompanied by serious damage, and in some cases loss of life. This shows an average of 55 cases of trains parting per day, and this on only a very small percentage of the railway mileage of the United States. Of the above cases, fortunately most occurred at speeds under 20 miles per hour, and many of them occurred just as the trains were pulling out after having slacked up. On one road where an exceedingly rigid investigation of every case of train parting has for some time been made, it was found that only 0.78 of 1% of the cases occurred in connection with the application of air brakes, and this experience seems to be substantiated by nearly all the reports. The following table, tabulated from the replies to our circular of inquiry, will give a good idea of the comparative frequency of trains parting from different causes:

Number of cases due to:		Per ct.
Broken links and pins	1,517	26.27
Link and pin drawbars in addition to above	1,081	18.72
Total due to use of link and pin drawbars	2,598	44.99
Broken coupler spindles	708	12.26
Broken coupler pockets	86	1.49
Defective draft rigging	228	3.94
Failure or defects in M. C. B. couplers or their attachments	2,155	37.32
Total number of cases in 105 days	5,775	100.00
Average number of cases per day for 31 roads	55	....

In connection with M. C. B couplers and attachments which caused cases of trains parting, the details are as follows:

Number of cases due to:		Per ct.
Worn knuckles	195	9.05
Broken or defective locks	886	41.11
Excessive amount of slack in draft rigging	672	31.13
Improper adjustment of uncoupling attachments	234	10.86
Other miscellaneous causes	168	7.79
Total	2,155	99.94

The foregoing figures give much food for reflection and action. Your committee might enlarge on the data given and cover many pages in the discussion of the subject assigned us, but as busy railway officials look for results

*Report of a Committee of the Master Car Builders' Association, presented at the annual convention at Old Point Comfort, Va., June 8, 1897, by A. M. Waitt, General Master Car Builder, L. S. & M. S. Ry.; W. Lavery, Asst. Supt. Motive Power, N. Y., L. E. & Wn. Ry.; F. H. Soule, General Car Inspector, N. Y., N. H. & H. R. R.; D. Hawksworth, Supt. Motive Power, Bur. & Mo. R. R. R.; and B. E. Thomson, Chief Joint Car Inspector, Williamsport, Pa.

in the most direct way rather than through long dissertations, it will simply be our purpose to call attention to the most important conclusions to be arrived at from the information above given, and to suggest some practical lines on which active effort is at once needed in all of our mechanical departments.

(1) It is seen that we are fully justified in considering links and pins a very weak and unsatisfactory feature in connection with coupling arrangements, and we should give all haste possible to consigning our remaining link and pin drawbars to "innocuous desuetude" and rid ourselves of one source of much expense, which it seems impossible to avoid as long as we are compelled to use the link and pin drawbar to any considerable extent.

(2) We see that 708 coupler spindles broke, causing trains to part, as compared with only 86 similar cases from broken pockets. From this we are surely justified in unhesitatingly condemning the further use of spindles in all new couplers applied to cars in the future. There is very little excuse for perpetuating the spindle coupler, and as it is shown by the above figures to be an especially weak device, it is the recommendation of your committee that the Master Car Builders' Association put themselves clearly on record, in connection with their Recommended Practice, against the continuance of the use of spindle rear end attachments for couplers, and in favor of the general use of pocket rear end attachments, which rarely give out.

(3) We notice, in connection with M. C. B. couplers that have caused trains to part, that 906 cases, or 42.04%, have occurred from excessive slack in the draft rigging or improper adjustment of the uncoupling attachments. The result of both of these wrong conditions was clearly shown to one of your committee recently in riding on a passenger train watching a freight train going in the same direction on a parallel track of a neighboring road. In this train were a large number of cars equipped with M. C. B. couplers; on at least 50% of these cars the draft springs were compressed to such an extent and the uncoupling attachments were so short, that the connection between the uncoupling lever and the lock was drawn taut, and apparently, in some cases, the lock was partially raised. With such a condition existing, it is quite easy to see how the application of the brakes on cars in the rear, or a sudden pulling out of the engine, might compress the draft springs enough to open fully the lock and allow the train to separate. The condition of the cars, on the train above referred to, is a condition that the reports tabulated above would indicate as existing on nearly 50% of the cars where "break-in-twos" occur. In overcoming these two prolific sources of danger, we have one of the most fruitful fields for work. Excessive slack in draft gear must be overcome by the exercising of greater care in maintaining draft rigging on cars in first-class condition, promptly replacing broken springs, bent followers, springs that have a considerable permanent set, and preventing the use of short springs. It should be considered a defect rendering a car unsafe to run if it has 1 in. or more play in the draft rigging, so that by the hand the drawbar can be pushed back or pulled out 1 in. or more. It should be considered that a car is in improper condition to run when the uncoupling attachments are so arranged that in their released position there is less than 2 ins. slack in the chain connection between the lock and the arm of the uncoupling lever. It is true that a large percentage of cars running have a less amount of slack in the uncoupling chain. This, in connection with the large number of trains parting, gives a most urgent reason for having a safe limit in connection with the slack in our uncoupling arrangements, and your committee would impress upon the representatives of every road in the association the importance of requiring a proper adjustment of the uncoupling attachments and draft rigging on their cars in accordance with the preceding suggestions.

It is noticed that on many cars the end of the lifting arm of the uncoupling lever does not extend out as far as the center of the lock or lock pin. In good practice it should extend a little beyond the center, and attention to this point would materially improve the foundation uncoupling rigging in our freight equipment. In this connection your committee would urge the necessity of inventive genius in designing a simple uncoupling device so constructed that it will not lift the lock and uncouple the car until the coupler has been pulled out three or four inches from its normal position. Such a device would be very beneficial in overcoming a large number of cases of uncoupling due to improper adjustment of uncoupling attachments and excessive slack in draft gear.

(4) The second largest source of trains parting in connection with M. C. B. couplers is due to broken or defective locks. This cause accounts for 886 cases, or 41.11%. It is unquestionably true that the locks now in use in most of the M. C. B. couplers are not all that they should be. Many of them are so constructed that they will creep up by the peculiar pinching action produced by the motion of the car, and many of them, dependent upon gravity, are lifted from their proper position by sudden blows which may be caused by the trains slacking up. These and other defects which have developed in the large majority of locking devices, supplemented by the expressions from the representatives of nearly every one of the roads heard from by your committee, warrant the committee in stating that it believes it necessary that coupler locks should be provided in some simple and effective way with a positive lock, which will prevent their being lifted from their locked position by any of the shocks, jars or motions produced in running cars; in other words, that there should be a lock to a lock.

(5) The preceding table shows that 195 cases, or 9.05% of all cases of uncoupling of M. C. B. couplers were due to worn knuckles. In view of the rapid increase in the number of M. C. B. couplers in use, and the fact that a large part of them have been in service long enough for the knuckles, and possibly the couplers themselves, to become considerably worn, and as it has been clearly shown that knuckles and couplers worn beyond a certain limit will permit of the knuckles passing the locks or the cars becoming separated without the knuckles opening, therefore, your committee would recommend that during the coming year an investigation be made, by a committee for that purpose, as to the limit of safe wear that can be allowed in knuckles and couplers, with a view of recommending to the association some simple and practical method for inspectors and others to use in determining when M. C. B. couplers or knuckles have become worn or distorted beyond the safe service limit.

In conclusion, the committee would call attention to 168 cases, or 7.79% of uncoupling between M. C. B. couplers due to miscellaneous causes. Most of them can be assigned to broken couplers or knuckles. By the Rules of Interchange and the decisions of the Arbitration Committee, it has been declared that M. C. B. knuckles and couplers can be broken without any unusual rough handling. As the breakage of an M. C. B. coupler represents a loss of from $5 to $8, it behooves railway companies to protect themselves as far as possible against unnecessary damage of this kind, not only from the standpoint of doing so to prevent cases of trains parting, but from the standpoint of the cost of renewing such couplers when they are broken. And in this connection your committee would recommend for the consideration of the roads representing the association, the application to their cars of either rigid, or, preferably, spring buffer blocks. The use of such buffer blocks under severe tests in collisions has conclusively proven that both the couplers and the draft rigging are protected and saved to a very large extent where the blows are taken by double buffer blocks, which conduct the shocks through the car and train in a line with the floor timbers and sills.

BREAKING LOAD TEST OF A CONCRETE AND EXPANDED METAL FLOOR AFTER A FIVE-HOUR FIRE TEST.

In Engineering News of May 27 brief mention was made of a test to determine the breaking strength of a concrete and expanded metal floor arch built by the Central Expanded Metal Co., of New York city, after the floor had undergone the standard fire test of the New York Building Department. This test was conducted by Mr. Geo. Hill, M. Am. Soc. C. E., and is fully described in his formal report as follows:

On May 20th last a test to destruction was made of the expanded metal and concrete arch built by the Central Expanded Metal Co. for testing purposes. This arch was tested by the Building Department on April 23 under fire and water, the temperature of 2,000° being maintained for five hours, and then quenched with a hose stream under 60 lbs. pressure. The effect of the stream was to remove all of the plaster and the concrete under the wire mesh, so that the wire mesh was exposed and not in immediate contact with the concrete at the part tested. The drawings, Figs. 1 and 2, submitted herewith show the way in which the concrete was cut through for the admission of the clamps of the testing machine, the position of the plunger of the testing machine, and the other data in connection with the test.

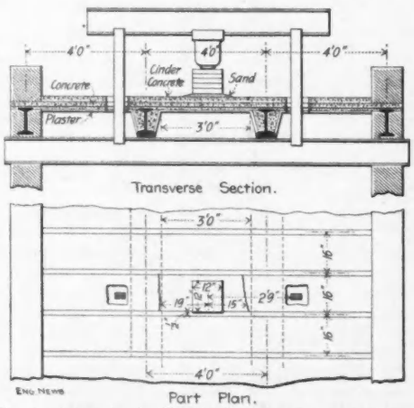

Fig. 1.—Apparatus for Testing Breaking Strength of Concrete and Expanded Metal Fireproof Floor.

Central Expanded Metal Co., New York, Builders.

The pressure of the machine was applied through yellow pine blocks 12 ins. square, and about 1 in. of sand to an area of 1 sq. ft. on the arch. The arch had been exposed to the weather during the period elapsing from the test of the Building Department to the time when the destruction test was made. The testing machine was calibrated, and the pressures recorded by it were accurate. The pressure was first applied at a practically uniform rate, and after a lapse of 3¼ minutes a load was reached of 12,500 lbs., when a small crack appeared 10

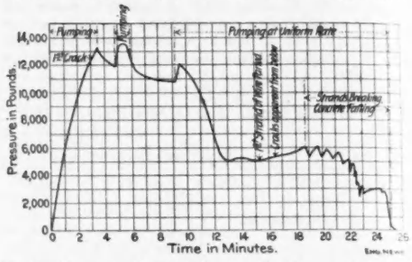

Fig. 2.—Pressure Diagram Showing Resistance of Concrete and Expanded Metal Floor Against Pressure.

ins. from the center of the arch, which was almost immediately over the reinforcing of the slab by the beam protection. The pressure was increased to a load of 13,200 lbs. at 3½ minutes, and then relieved to 11,800 lbs. Pressure was then increased again and reached load of 13,500 lbs., which was the maximum. Further application of load resulted in increased deflection and decreased load. The pressure was again relieved until it lowered to 10,800 lbs., and then again increased to 12,000 lbs., after which there was a continuous failure of the arch. Each time the arch was relieved of pressure it recovered some strength. The deflection was continually increased at a uniform rate and the strength of the arch decreased to 5,000 lbs. At this point there appeared to be an intimate contact between the concrete and the expanded metal. The strength of the arch uniformly increased, and then the first strand of wire in the expanded metal mesh broke at 5,050 lbs. The strength increased to 5,400 lbs., at which point cracks appeared on the underside of the slab. The strength continued to increase to 6,000 lbs., at which point the strands of the wire mesh again parted. After this the strength varied up and down,—the strands breaking and the concrete dropping below. The total deflection amounted to about 6½ ins., of which about 3 ins. were obtained by forcing the concrete through the meshes of the expanded metal. The second crack shown on the drawing occurred shortly after the first crack,—but without making any noise which was audible. All of the rupturing of the expanded metal occurred under the point of application of the load. There appeared to be no movement of any kind of the expanded metal through the concrete where the metal was imbedded in the concrete.

QUALITY OF THE BOILER-WATER SUPPLY OF A PORTION OF NORTHERN ILLINOIS.*

By James A. Carney.**

The quality of water for steam boilers is a serious question in Illinois, and has been the occasion of many investigations, undertaken either for the discovery of sources of a better supply, or for the purification of the supplies already at hand.

The sources of supply of which this paper treats lie along the right of way of the Chicago, Burlington & Quincy R. R. Co., and form a nearly straight line from Chicago, Ill., to Burlington, Iowa. The supplies consist of surface, ground and deep-well waters.

The surface waters are derived from the drainage of the watershed and from springs. The surface of that portion of the state which furnishes these waters consists of glacial ridges, till plains and loess-covered till; the water partaking of the soluble portion of these formations. No separate study has been made of the spring waters, but they can probably be classed with the ground waters.

The ground waters are derived from glacial drift, which covers the older rock to a depth of from 10 to 200 ft. The drift is of variable composition; in some portions it consists of clean gravel; in other portions of various mixtures of clay of several varieties, gravel boulders or sand. It is this great variation that makes the composition of the ground waters so uncertain.

The deep-well waters are all from St. Peter's sandstone. This formation occurs immediately below the Trenton limestone and varies in thickness from 10 to 300 ft. It consists of fine round grains of sand, more or less cement-

*Abstract of a paper read at the Chicago meeting of the American Institute of Mining Engineers.

**Chemist of the Chicago, Burlington & Quincy R. R., Aurora, Ill.

ed together. It is free from fossils, although ripple marks have been found in the out-crop along the Rock River. In Illinois the formation is generally from 500 to 1,200 ft. below the surface.

Methods of Analysis.

The ordinary methods of analysis were used in the analyses here reported, the acids and bases being determined in separate portions, and salts calculated as follows:

The chlorine was first united with the sodium, and the excess, if any, with the magnesium. The sulphuric acid was united with the sodium (if any sodium was left after satisfying the chlorine); then with the calcium; and finally, if there was still an excess of sulphuric acid, it was united with the magnesium. The calcium, magnesium and occasionally sodium in excess were calculated to carbonates. The oxides consist of silica, alumina, and iron oxide, and are reported as such, no attempt being made to combine them with acids.

Analyses by Ellis for oxides, calcium and magnesium were made by standard methods. A separate portion was washed with water to determine the alkalies and the soluble calcium and magnesium salts; the alkalies consisting of sodium chloride and sodium sulphate were reported as alkalies, and the soluble calcium and magnesium were calculated to sulphates. This method works well with surface waters, but cannot be used with ground and deep-well waters.

Both schemes of calculation are open to criticism, but the first one has been found to meet our wants fully, and is an excellent method for comparing sources of water supply.

The results of the analyses are compared as follows (condensed from the full tables in the paper.—Ed.):

Analyses of Waters on the Line of the Chicago, Burlington & Quincy R. R., Chicago, Ill., to Burlington, Iowa.

Results of Analyses.

	Surface waters.	Ground waters from shallow wells.	Deep waters from artesian wells.
Sodium chloride	0.22 to 4.38*	0.78 to 3.45	1.62 to 41.35
Sodium sulphate	0 to 0.28	... .	0 to 56.73
Calcium sulphate	0.19 to 5.18	0.18 to 41.08	0 to 26.60
Calcium carbonate	3.68 to 10.18	0 to 18.11	0 to 11.72
Magnesium chloride	....	0 to 2.35	....
Magnesium sulphate	0 to 9.11	0 to 7.11	0 to 7.36
Magnesium carbonate	0 to 9.27	6.17 to 18.63	4.58 to 12.28
Oxides, iron, silica, etc.	0.17 to 1.40	0.11 to 1.47	0.03 to 0.78
Total solids	7.80 to 24.17	22.39 to 65.81	19.37 to 108.04
Incrusting solids	7.30 to 19.79	20.77 to 65.03	10.98 to 39.24
Sodium carbonate	....	....	0 to 3.34

*The higher figures include sulphates.

A comparison of the average results and a close inspection of the analyses of the different classes of water show that the surface waters are quite uniform. The sodium salts are never in sufficient quantity to cause trouble from foaming, and the sulphates of the alkaline earths are low, generally less than five grains per gallon, while the main bulk of the solids is composed of carbonates of calcium and magnesium. These form a comparatively soft scale, and are the least injurious of the scale-forming solids which occur in natural waters.

The ground waters vary from fair boiler waters to those which are positively injurious to boilers. The characteristic of these waters, as compared with surface waters, is the comparatively large quantity of alkaline earth sulphates which they contain. They are low in sodium salts, and do not cause trouble from foaming; but they do form a bad scale. A calcium sulphate scale is very compact and hard, and seriously interferes with the making of steam. An experiment on the effect of scale showed that a calcium sulphate scale, about 0.11-in. thick, caused a loss of evaporating efficiency of over 7%. Two of the waters contain magnesium chloride. This is corrosive, and renders a water unfit for boiler use. The principal feature of the ground waters is their entire lack of uniformity. Analysis of several ground waters throws no light on what the next may be.

The deep-well waters are all from St. Peter's sandstone. The characteristics of these waters, with the exception of the Mendota well, where the sandstone comes within 460 ft. of the surface, are large quantities of sodium salts, both chlorides and sulphates. The incrusting solids vary greatly in quantity as well as in composition, some being very high in calcium sulphate, and others containing no alkaline earth sulphates whatever. These waters cannot be successfully used for boiler purposes, on account of the foaming tendency due to the large quantity of sodium salts.

Foaming.

Foaming is caused by interference with the free escape of steam from the water in the boiler, and manifest itself by the rising and frequent appearance of boiling of the water in the water-glass, and by water in the steam. This does not mean wet steam, as ordinarily defined, but steam that contains visible drops of water. There are three principal causes of foaming: (1) Sodium salts; (2) mud or suspended matter; and (3) organic matter.

Mud and organic matter can be removed by filtration, but there is no known method of getting rid of sodium salts; and because of this fact I will mention the foaming caused by sodium salts only.

The sodium salts in solution increase the surface tension and thereby prevent the free escape of steam from the water. Bubbles, formed in rapid succession, constitute a froth which fills the steam space of the boiler and passes over with the steam. The height to which the froth will rise depends upon the rapidity with which the steam is made. This is very nicely illustrated by blowing air into a weak soap solution. The more rapid the introduction of the air, the larger quantity of bubbles formed, and the higher they rise before they break.

It has been found by actual experience that locomotive boilers will foam with from 75 to 200 grains of alkali per gallon, depending upon how much mud or suspended matter is in the boiler, while stationary boilers have been successfully run without foaming with a concentration of sodium salts amounting to 650 grains and more per gallon.

The following explanation is offered to show why a stationary boiler will run successfully with 650 grains of sodium salts per gallon, while a locomotive boiler will foam on from one-third to one-sixth of that quantity of alkali.

A locomotive boiler with a shell 60 ins. in diameter, tubes 12 ft. 4 ins. long, and a 9 ft. firebox, has a heating surface of 1,689 sq. ft., and develops 1,000 HP. when doing maximum work. The evaporating surface is 96.5 sq. ft. Therefore, 0.59 HP. is developed per sq. ft. of heating surface and 10.3 HP. per sq. ft. of evaporating surface.* On the other hand, a stationary boiler, with a shell 66 ins. in diameter and 18 ft. long, has a heating surface of 736 sq. ft. and develops 100 HP. The evaporating surface is 84 sq. ft. Therefore, 0.13 HP. is developed per sq. ft. of heating surface, and 1.19 HP. per sq. ft. of evaporating surface.

A stationary boiler has 4.36 times as much heating surface per HP. for making steam and 8.70 times as much surface per HP. for the escape of the steam after it is made, as a locomotive boiler. Since foaming is determined by the rate of formation and the escape of bubbles of steam, it will readily be seen that a stationary boiler with 8.70 times the evaporating surface per HP. will run successfully on a quantity of alkali in the water that would render the locomotive boiler useless.

The Location of Reservoirs.

In locating reservoirs for boiler supply great care must be taken to see that the drainage is surface water only, and that there is no chance of contaminating waters getting into the reservoir.

The reservoir at Kewanee was abandoned on account of the contaminating effect of the waters draining into it. This water was originally as good as that of our other artificial ponds, but water from an artesian well high in sodium salts, and refuse from a galvanizing plant, have so deteriorated the supply that it is impossible to use it in a boiler.

Conclusions.

Water for boiler purposes should be taken as much as possible from streams, lakes, or artificial ponds. The use of sub-soil water is open to objection, unless an analysis shows the water to be sufficiently good for boiler use. Waters from deep wells in St. Peter's sandstone will cause foaming unless very carefully handled. The large quantity of sodium salts prevents the formation of scale, and, with regular washing out, these waters have been used with success in stationary boilers, but for locomotive use they are a failure.

*By heating surface is meant the square feet of water exposed to the heat from the fire. By evaporating surface is meant the square feet of surface of water not coming in contact with any portion of the boiler.

CHARLES BENJAMIN BRUSH.

Charles Benjamin Brush, M. Am. Soc. C. E., died at his residence in New York city on June 3, after a long illness. Mr. Brush was born in New York city on Feb. 15, 1848. He was the son of Jonathan Ethelbert Brush and Cornelia (Turck) Brush, and was graduated as a civil engineer from the University of the City of New York. His first professional service was as a member of the engineer corps of the Croton Aqueduct Department, in 1867-69. He commenced an independent practice as a civil engineer in 1869; but in 1874 he was made Adjunct Professor of Civil Engineering in the University of the City of New York; in 1888 he became Professor of Civil Engineering and was Dean of the School of Engineering in the same institution. He was elected an Associate of the American Society of Civil Engineers on Sept. 6, 1871; became a Member on Sept. 5, 1877; was a Director of the Society from 1888 to 1891, and a Vice-President in 1892.

Mr. Brush was very extensively engaged as a consulting engineer upon water-works design and construction throughout the United States. In this work he was connected with Mr. Arthur Spielmann from 1869 until the death of Mr. Spielmann in 1883; after the latter date Mr. Brush conducted his business alone until January of 1896, when he took as his partner Mr. Walter F. Whittemore, the firm name being Charles B. Brush & Co.

Space forbids more than a brief mention of the works with which Mr. Brush was connected as engineer. Among the more prominent water-works were those of the Cincinnati, Chicago, Memphis, Jamestown, East New York, Passaic, Easton and Montclair. He was Chief Engineer of the Hoboken Land and Improvement Co., of the North Hudson County Railway Co., of the Hoboken Ferry Co., and of the Hackensack Water Co. The development of the latter company was especially due to his careful study and management. He was called upon for expert examination of the foundations for bridges at 181st St., and at Second and

CHARLES B. BRUSH.

Third Avenues over the Harlem River in New York, and at the Thames River bridge at New London, Conn. He was engineer for the contractor in the construction of the Washington bridge, over the Harlem River, and Associate Engineer for the proposed New York & New Jersey bridge, over the Hudson River, in New York city. He was for a time Engineer of the Hudson River tunnel; Engineer of sewers in North Hudson County, in New Jersey, and in Irvington, New York; and among the other water-works upon which he was engaged in some engineering capacity may be mentioned those at Greenwood Cemetery, Plainfield, Highland Falls, Syracuse, Portsmouth and Suffolk, Va., Far Rockaway, Alliance, O., Kansas City, and South Hampton, N. Y.

Personally, Mr. Brush was a man of sterling integrity, painstaking in his professional work; tireless in his energy, and esteemed by every member of the profession who knew him. He was broad-minded and charitable, almost to a fault, though of exceptional business ability. He was married in 1883, and a widow and three children survive him.

A NEW CHEMICAL FIRE EXTINGUISHER consisting of a dry powder has recently been invented and is soon to be placed on the market. The powder appears to be as efficacious in extinguishing flame as are the liquids used in the best chemical fire extinguishers, and it has, of course, the enormous advantage that it does not injure anything upon which it falls. The benefit which such a means of fighting fire would confer in libraries, offices, residences, and places where even a small stream of water may do great injury to books, pictures, clothing and similar valuable and easily injured articles are obvious. The material was invented by a resident of Springfield, Mass., and a company is now being organized in New York city to manufacture the material on a large scale, together with appliances for throwing it upon fires, and place them upon the market. The company's headquarters are in the Syndicate Building, New York city.

ENGINEERING NEWS
AND
AMERICAN RAILWAY JOURNAL.

Published every Thursday at St. Paul Building, New York. Entered at the Post Office, New York, as Second Class Matter.

D. McN. STAUFFER, CHARLES WHITING BAKER.....EDITORS.
WM. KENT, E. E. B. TRATMAN, M. N. BAKER, CHAS. S. HILL, A. B. GILBERT.....ASSOCIATE EDITORS.
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ALFRED E. HORNFELD, New York.....
F. A. PECKHAM, Chicago.....ADVERTISING REPRESENTATIVES.

PUBLICATION OFFICE.....St. Paul Building, New York.
CHICAGO OFFICE.....1636 The Monadnock.
LONDON AGENCY: SAMPSON, LOW, MARSTON & CO. (Limited), St. Dunstan's House, Fetter Lane.

SUBSCRIPTION RATES: United States, Canada and Mexico, One Year, $5.00; 6 months, $2.50; 2 months, $1.00; Single copies, 15 cents. To all other countries in the Postal Union: Regular Edition, One Year, $7.60, (31 shillings); Thin Paper Edition, One Year, $6.31 (26 shillings). Mailing addresses may be changed at will by sending both old and new address. We shall be obliged if subscribers who fail to receive their papers promptly will notify us without delay. The number on the address label of each paper indicates when subscription expires, the last figure indicating the year and the one or two preceding figures the week of that year; for instance, the number 326 means that subscription is paid to the 32d week (that is the issue of Aug 6) of the year 1896; the change of these figures is the only receipt sent, unless by special request.

ADVERTISING RATES: 20 cents per line agate measure. Want notices, special rates, see page 22. Rates for standing advertisements sent on request. Changes to standing advertisements must be in hand on Monday afternoon; new advertisements, Tuesday afternoon; transient advertisements by Wednesday noon.

At the convention of the Master Car Builders' Association in 1893, a form of contract for the purchase of cast-iron car wheels by railway companies was adopted as a "recommended practice" of the Association. Under the terms of this contract the car-wheel maker was to receive a given sum per wheel, and was to be credited according to the length of service his wheels gave or debited if the wheels wore out sooner than they should.

One manifest objection to the purchase of car wheels by this plan was that a transaction between buyer and seller might last for a dozen years or more, during which time either the railway or the foundryman, or both, might become insolvent, and the latter might very likely retire from business. Another objection was that it involved a vast amount of complication and keeping of debits and credits by the railway company, and all over sums of money which were comparatively small. Finally, the guarantee of service which the car-wheel maker was required to give was so low that any wheel, except a very poor one, would come up to it.

For these reasons this proposed contract for chilled wheels has never come into general use, and last year a committee was appointed to report at this year's convention of the Association as to amendments to this contract. The plan which the committee presented to the convention this week at Old Point Comfort is substantially this: Railways are to buy from the car-wheel makers not wheels but wheel mileage. From every lot of wheels purchased the railway is to take at least 20% and wear them out under passenger cars and engine trucks. If in this service the wheels show an average mileage equaling a standard fixed by the committee, it shall be deemed that the mileage in freight car service will also be satisfactory. If the mileage of these trial wheels falls short of the average, the car-wheel maker must furnish wheels enough to make up the shortage or pay the difference in cash.

It appears to us, however, that this proposed method of car-wheel purchase is not likely to prove more popular than the old one. The very large proportion of companies which are running steel-tired wheels under passenger cars and engine tenders would be unable to buy wheels on such a basis; and there are very many roads which use chilled wheels under passenger cars that would not be able to use nearly one-fifth as many wheels in this way as they require for freight car service.

The advantages of paying for wheels in proportion to the service which they give is evident; but no plan thus far proposed seems likely to commend itself as a practical and generally acceptable method of effecting this.

The recent retirement, for physical disability, of Mr. Thomas C. McCollum, of the Civil Engineer Corps of the U. S. Navy, creates a vacancy in that small corps, and it is reported that there are already a large number of applicants for the position. The practice in recent years has been to appoint the man who could command the largest amount of personal or political influence, without special regard to the character of the previous experience or professional training of the applicant. That this is an unwise and unsafe method of procedure is so evident as to need no proofs. Upon this small corps rest grave responsibilities; for the proper design and the safe construction and maintenance of all the navy yards and drydocks of our governmental establishment.

The corps at present contains a number of engineers who are universally respected for their professional abilities, and who are thoroughly competent to perform the responsible duties imposed upon them in connection with the design of drydocks, etc. But as the inspection of the actual construction of these docks is practically in the charge of the younger members of the corps, the excellent work of the seniors may be rendered of no avail if this work of inspection is inefficiently or carelessly performed. Very much depends upon the manner in which these young men fulfill the duties imposed upon them. The cost and success of future changes or repairs to the structure may be determined by the notes made during construction, upon the character of the soil penetrated; the hidden obstructions met with; the depths to which sheet piling is driven, or the care with which levels and dimensions are given. And further, as all advance in the corps is now by regular promotion, it must not be forgotten that the future efficiency of the corps rests solely upon the character of the material admitted to the lower grades. For these reasons the utmost care should be observed in selecting candidates for admission to this small body of engineers, and a rigid, properly-conducted system of competitive examination for personal character and professional fitness seems to be the only method which will secure for the government the kind of service demanded. There is no sentiment in engineering work and there should be no favoritism in the selection of engineers. Merit and fitness for the duties imposed should alone determine admission to a corps upon which so much responsibility rests, and to a position where careless or inefficient work may mean so much to the government in wasted money and effort and in the possible dangerous blocking of the government business. If a competitive examination were ordered, there would be an abundance of good material applying for an engineering position that is, or should be, in every way so desirable; and it is to be fervently hoped that the naval authorities will make this new departure in their procedure to fill the vacancy caused by the retirement of Mr. McCollum.

Since writing the above, we learn that an examination has been ordered by the Secretary of the Navy for the selection of an engineer to fill the place left vacant by the retirement of Mr. McCollum; and that this examination is to be held in Washington on June 14. But we fear that the Secretary of the Navy does not fully appreciate the real importance of the place to be filled nor the true requirements of the position. Instead of appointing a board of expert engineers to examine into the professional qualifications of the applicant, this board has been made up of one line officer of the Navy, one naval constructor, and only one civil engineer. Such a board is not the one contemplated in our note above, nor is it one best constituted to obtain the type of man demanded by the present and future interests of the Civil Engineer Corps of the U. S. Navy.

We would respectfully suggest to Secretary Long that if an examination were to be held of candidates for an appointment as a surgeon in the Navy, the examining board would without doubt be made up solely of members of the medical profession. Secretary Long is himself a lawyer; but if his original admission to the bar were in question we are convinced that he would not approve of an examining board made up, say, of the Sheriff, the County Clerk and one member of the legal profession. Yet such a board would be very much akin to the one now appointed to test the technical qualifications of an applicant for a position in the Civil Engineer Corps of the Navy. The one engineer on that board will doubtless seek to fairly test the professional abilities and training of the applicants; but what are the other members of the board to do?

Are they competent to devise questions for testing the engineering ability of the applicants or to judge of their ability from the answers that are given? If they are not, why are they put upon the board at all? As matters stand now the one engineer on the board must actually do the work of testing the professional abilities of the candidates, and unless the two other members are to interfere and overrule the results of his investigation, he might as well have been given sole charge and full responsibility in the first place.

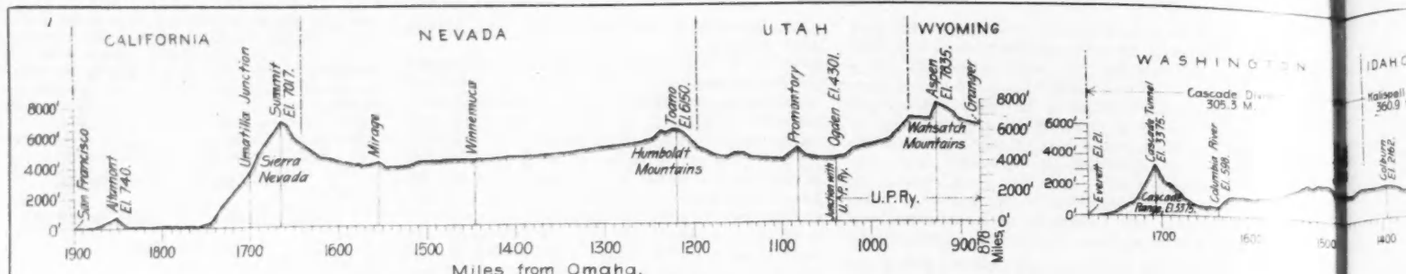
If a man from civil life were to be selected for a position as a naval constructor, we are confident that Secretary Long would impanel a board of men experienced in marine architecture to make the choice. If a question of navigation or of gunnery were to be settled, a board of line officers would be formed to decide it. Why not apply the same principle when the profession of civil engineering is concerned?

It appears to us that the present constitution of this board is virtually a declaration by the higher authorities that the civil engineers of the Navy are not to be trusted to fill a vacancy in their own corps. This slight put upon these able and respected officers is wholly undeserved, and it ought to be withdrawn. The Naval authorities will do well to return to the custom of former years, and make at least a majority of the examining board, civil engineers.

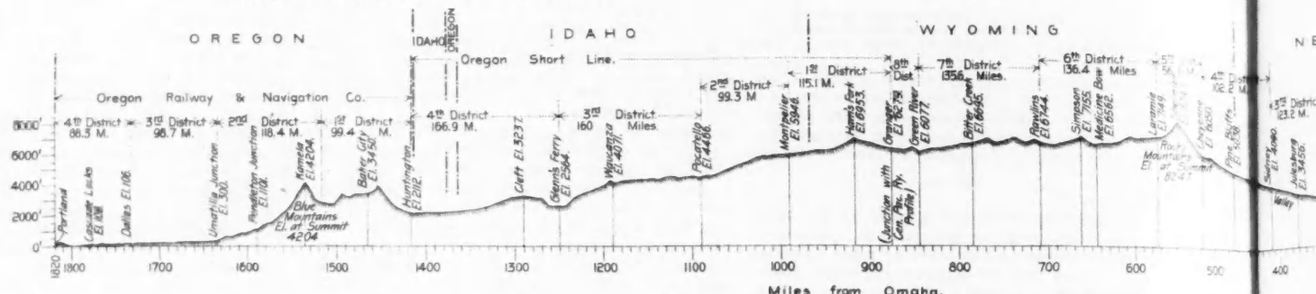
Mr. McCollum, whose retirement creates this vacancy, was selected by a board made up of two line officers and three civil engineers of the corps; he was one of a number of applicants, and received his appointment solely upon merit and because he was the best fitted professionally and personally of all who were examined. His record in the corps was an exceptionally good one and gave proof of the fairness and wisdom of the course then adopted.

When a hapless inventor brings some alleged improvement to the attention of an American railway man, the formula which always suffices to turn down the applicant and blast his hopes is: "too complicated." They do these things differently on the other side of the water. In France and Germany, especially, it seems as if the inventor who could load down a machine for railway purposes with the most complications receives the warmest welcome. As a curious example of this, we illustrate elsewhere in this issue a locomotive for the Bavarian State Ry., which carries a pair of small "auxiliary" driving wheels that are normally lifted from the rail and idle. Their only earthly use is when the locomotive is starting a train and the adhesion of the main drivers is insufficient, these auxiliary wheels are dropped to the rail, part of the weight is transferred to them from the truck wheels and steam is turned on the cylinders that drive them. Certainly, from an American standpoint it seems to be the height of absurdity to build a complete engine, including the valve gear, for the sole and only purpose of avoiding the use of a side rod, and to carry a pair of wheels dangling in the air for hundreds of miles for no other reason than that they may be used at a few points upon the line, where the engine would otherwise be unable to haul its load.

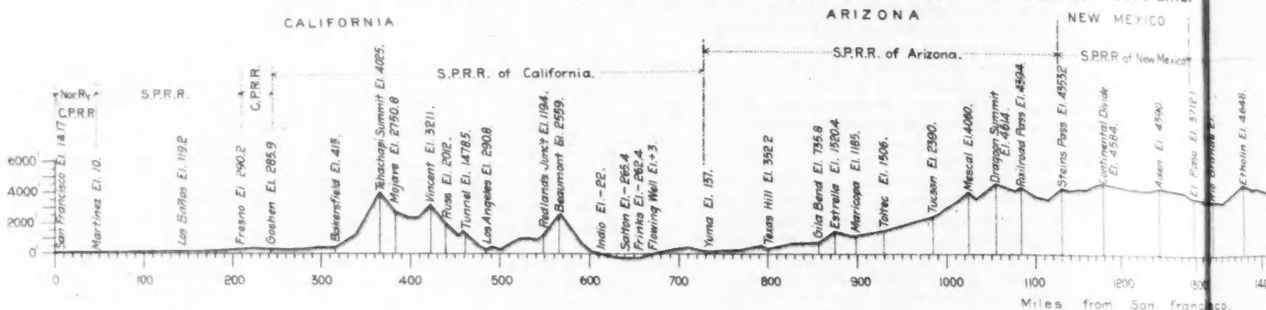
As for the compound locomotive to which this interesting apparatus is attached, a study of the drawing, which we reproduce from our German contemporary, shows it to be fearfully and wonderfully made. If such complications were an essential feature of compounding, we fear that the compound locomotive would never meet with favor on American railways at least.



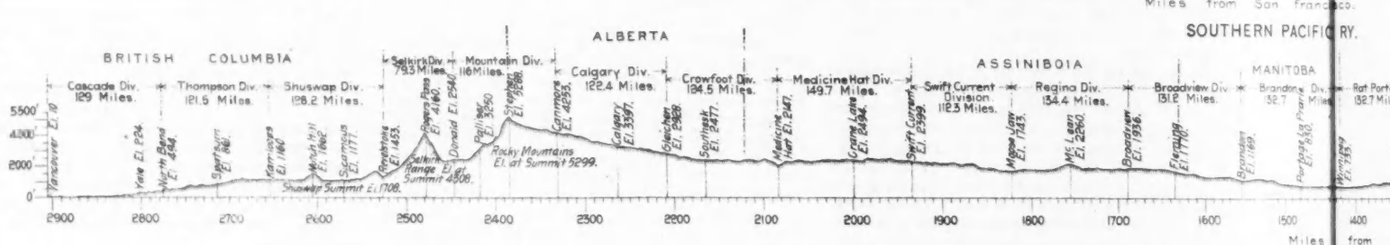
UNION PACIFIC RY. AND CENTRAL PACIFIC RY.



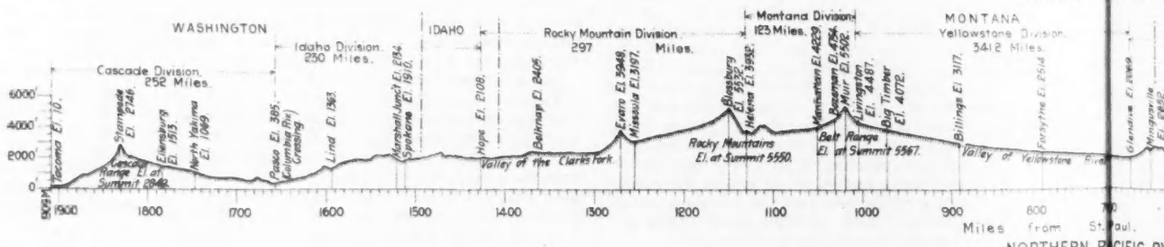
UNION PACIFIC RY., OREGON SHORT LINE AND OREGON RAILWAY & NAVIGATION CO.'S LINE.



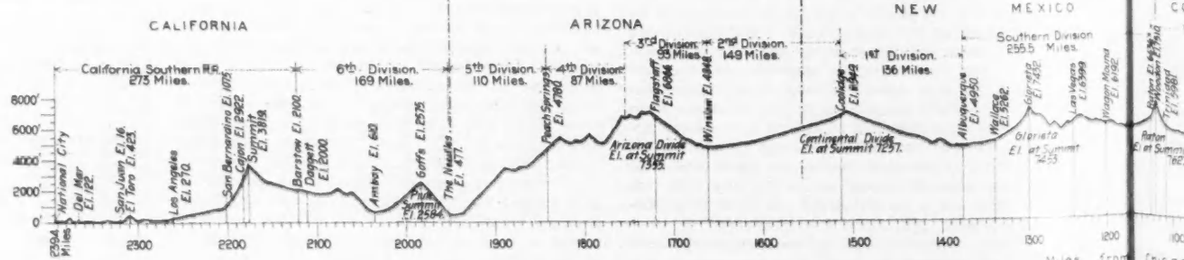
SOUTHERN PACIFIC RY.



CANADIAN PACIFIC RY.

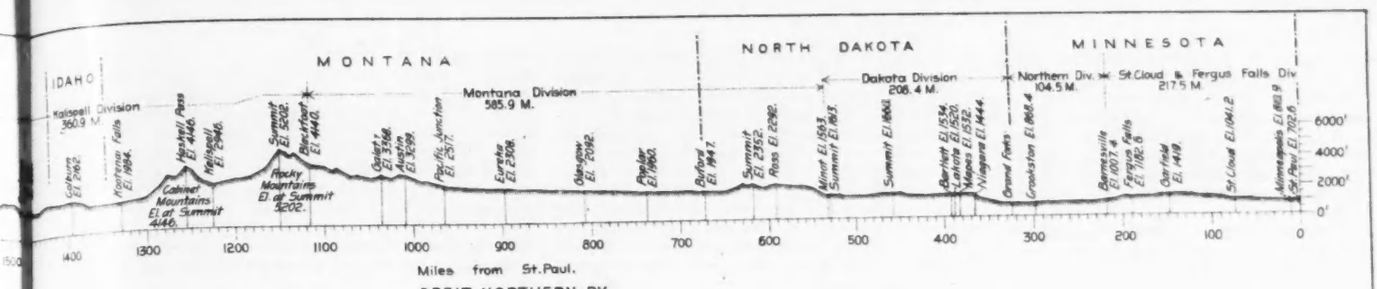


NORTHERN PACIFIC RY.

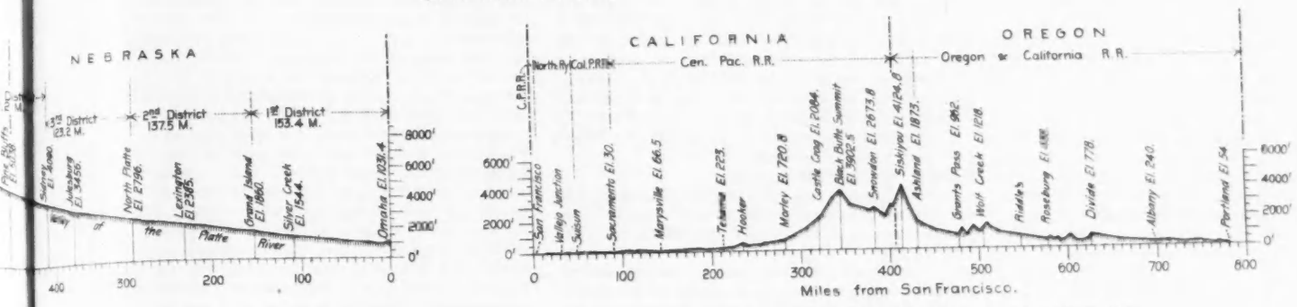


ATCHISON, TOPEKA & SANTA

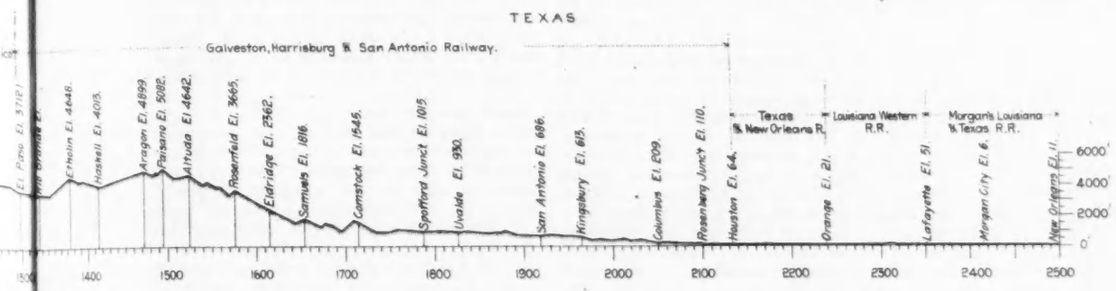
PROFILES OF TRANSCONTI

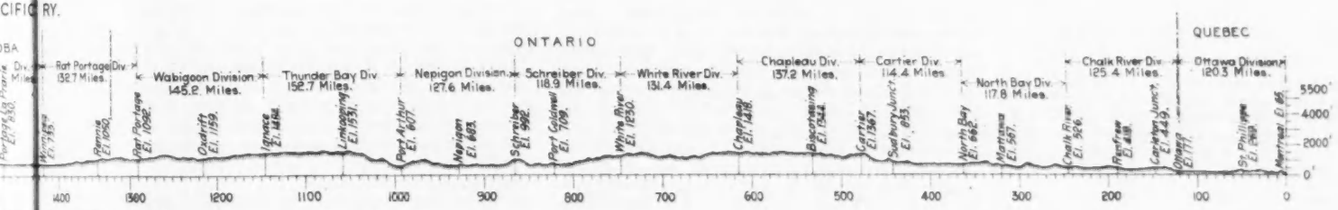


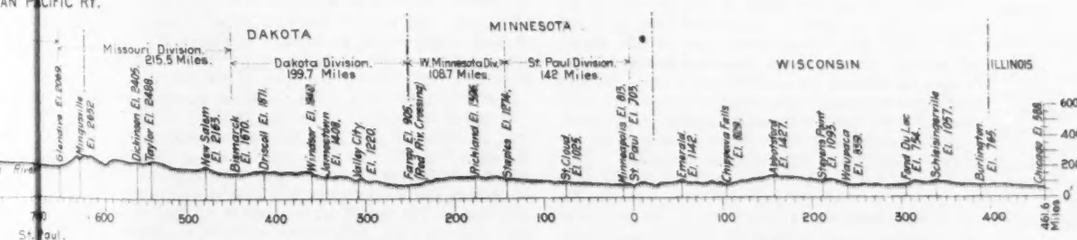
GREAT NORTHERN RY.

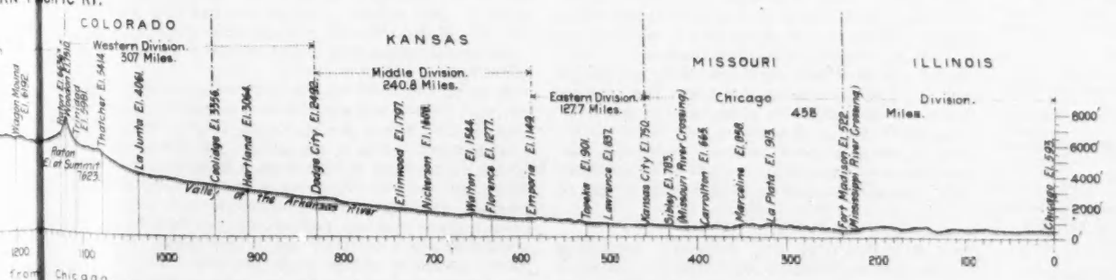


SOUTHERN PACIFIC RY. (SAN FRANCISCO TO PORTLAND.)









ANSCONTINENTAL RAILWAYS.

CHAS. HART & SONS, LITH., 20 VESEY ST., N. Y.

We print in another column a paper by Mr. Drummond, Locomotive Superintendent of the Caledonian Ry., of Scotland, which furnishes some good ammunition to those who still oppose the compound locomotive. Mr. Drummond says, among other things, that since the advantage of compounding lies in the decreased loss from condensation and re-evaporation, in the cylinder of a fast passenger locomotive, where the total length of time between the admission and release of the steam is often less than an eighth of a second, the amount of heat transferred to and from the walls of the cylinder must be very small. Doubtless this is one reason for the observed fact that the gain in compounding is much less with passenger than with freight locomotives. Mr. Drummond also lays stress on the jacketing of the cylinder by the hot gases of the smoke-box, a condition which does not exist in American locomotives.

Doubtless the most striking thing about Mr. Drummond's paper, however, is the table of results which accompanies it. It makes an American locomotive designer gasp to see Mr. Drummond calmly set down a steam consumption of 12.84 lbs. per HP. hour. When we come to investigate how this figure is obtained, however, we find it is computed from an indicator diagram and is found by adding together the work done propelling the train and locomotive itself, that expended in the blast-pipe and, remarkable to state, that employed in compressing the steam in the cylinder on the return stroke. By what right this latter quantity is included in the total horse-power developed passes the comprehension of an American engineer. As this quantity is about one-quarter as great as the horse-power used to propel the train, it is small wonder that Mr. Drummond's little Scotch locomotive develops a "total" horse-power which would do credit to a modern American express engine; or that its total consumption of steam divided by this quantity shows an economy which would do credit to a triple-expansion pumping engine.

Despite this erratic feature, however, Mr. Drummonds paper is one of no small interest; his plan of dividing the slide valve into two parts and giving a very short steam passage from the port of the cylinder at each end appears to be a scheme well worth looking into. We cannot agree with him in his condemnation of the compounding principles for locomotives; but we must certainly admit that many of the arguments he presents are sound and weighty ones.

In the description of the Greenleaf center bearing turntable, published in our issue of May 13, an error was made in assigning a title to the engraving of the strain sheet, shown on page 203. It should have been stated that this was the strain sheet and loading system for the company's standard riveted steel turntable, details of which, it may be noted here, were published in Engineering News of Sept. 10, 1896. It may also interest some of our readers to state that full details of the center bearings and girder construction for all three styles of turntables now made by the Greenleaf Turntable Co., are given in the article of Sept. 10 and May 13, mentioned.

In a description of a folding car step, published in our last issue, it was stated that the Ohio law requires a car-step to be not more than 16 ins. above the rail. A correspondent writes us that this is an error, and that the actual reading of the Ohio law is:

> To so regulate the rise from the station floor or platform to the top of the lowest step on passenger cars that it shall not be necessary to rise more than 12 ins. in one step.

AUTOMATIC CAR COUPLERS FOR ENGLISH RAILWAYS.

It may seem strange to many that English railways, where the protection of human life and limb, regardless of expense, is carried to great lengths, have never taken any steps toward the adoption of automatic car-couplings. The car-coupling reform has been in agitation in this country for over a score of years, and it is now well advanced toward completion; but Great Britain has yet to take the first steps toward the use of automatic car-couplings. The main reason for this is the undeniable fact that the loss of lives and limbs in coupling English railway cars is far less than in this country. It is not easy at first sight to see the why this should be. The number of cars in service and the amount of "shunting" work, as the English call it, is probably not greatly different in the two countries, yet in the last fiscal year for which the Interstate Commerce Commission reports are available, 251 railway employees were killed and 7,240 were injured in coupling and uncoupling cars in the United States, while on the railways of the United Kingdom, a Government report just at hand gives the totals for 1896 as 18 killed and 488 injured. It is possible that a difference in classification in the British figures accounts for a part of this difference; but even if we suppose that the British accidents in coupling cars are three or four times the above figure, the contrast between those figures and the United States figures is a striking one.

It is probable that the reason for the comparatively few coupling accidents in Great Britain is, first, that the British chain coupling, clumsy and rude as it is, is not so dangerous to operate as is the old American link-and-pin coupling, and second, the universal use of buffers in English cars, placed at the sides and not near the middle, as is customary in the United States.

But although coupling accidents may be relatively few in Great Britain, they are said to be on the increase and their number is such that the question of automatic couplings is beginning to be discussed over there. A recent number of the London "Engineer" contains an editorial upon the subject, in which the writer makes frequent reference to American experience; but betrays a large ignorance of some fundamental facts which American experience has developed.

To go back a little we may explain that the English railway car-coupling is simply a long-linked chain, and the end links drop over hooks which project from the end sills of the car. On passenger cars and a few fast freight cars the slack is taken up after the connection is made by a right-and-left-hand screw, but on the ordinary English "goods wagon" there is no means of taking up the slack.

"The Engineer" first discusses the question whether an automatic coupling is mechanically feasible, and concludes that this is the case. It warns inventors of such devices, however, that:

> One of the great objections to all automatic couplings is that they do not provide sufficient slack, and the slack is absolutely essential to the hauling of heavy trains, which the locomotive could not start unless it could pick it up, so to speak, wagon by wagon. We have seen several couplings tried which all worked well except in this respect; and a very little effort of invention will show that it is by no means easy to devise any automatic coupler which will at once work well on a sharp curve, and allow sufficient play between the wagons, while it will not be in danger of coming uncoupled when a train is running down hill pressing on the engine.

This has a very familiar sound to all who are familiar with the "battle of the couplings" in this country. It was not till the famous Burlington brake tests were made that the deeply-rooted idea that loose slack was an essential for starting heavy freight trains was given its death-blow here. It is now well understood by American railway men that loose slack in a coupling is a positive detriment to the proper and safe handling of a train, and the longer and heavier the train, the worse the difficulties which loose slack causes.

In the next place our contemporary fails to understand the status of uniform coupling in this country. It says:

> It is said that there are at this moment no fewer than 5,000 patents in the United States for automatic couplers, and they continue to be patented at the rate of three or four per week. This is all the more remarkable because some years ago the leading American companies bound themselves to use certain standard couplers, modifications of Janney's system.

Apparently our contemporary thinks that the adoption of the M. C. B. standard coupling has been of no effect, because of the continued grist of car-coupler patents. But our contemporary has too elevated an opinion as to what a car-coupler patent represents. If inventors want to go on inventing car-couplings, we let them do it, in this country. It's an innocent amusement, and one which is still indulged in by many persons of large ingenuity and small information. But our contemporary should understand that these car-coupler patents have no more relation to what the railways are actually doing than have the flying-machine patents.

But the most serious error which our contemporary makes is in its discussion of the question "Would automatic couplings pay?" It accepts, for the sake of argument, the proposition that a mechanically satisfactory coupling can be devised, and then it says:

> It is quite conceivable that there are 1,000,000 of wagons in Great Britain and Ireland. It would be impossible to alter these wagons and fit them with new mechanical couplers at a less cost than £3 per wagon; we are far more disposed to fix the cost at £5 per wagon. But even at £3 the proposed change would involve the expenditure of a colossal sum, three millions sterling. It is enough to state the case in this way to show how great are the financial difficulties which lie in the way, how great the commercial objections to the change. If we bear in mind that several large cities might be provided with perfect drainage works for that sum; that hospitals might be endowed; harbors of refuge constructed, roads and railways made, and benefits conferred on thousands of human beings, we begin to ask whether, after all, the £3,000,000 might not be better spent than on new railway couplings.

The present cost of M. C. B. standard couplers in the United States is in the neighborhood of $18 per car. Taking into consideration the very much lighter trains and locomotives of English railways, we should suppose that a coupler of the M. C. B. type suitable for English cars could be furnished for $12 per car. For the sake of argument, however, let us accept "The Engineer's" estimate of £3 per car; its £5 per car is evidently wide of the mark. Now if the English railways were to adopt an automatic coupler they would manifestly do as the railways of this country have done—make the change gradually. Thus on a great proportion of the cars, the cost of equipment would be simply the difference between the cost of the old and the new coupling.

Perhaps the initial cost of equipping the million cars in the United Kingdom might be as much as $10,000,000. English railway companies can borrow money, we believe, at 2½%. The annual interest charges against this sum at this rate would then be $250,000. The total casualties in 1896 "from coupling or uncoupling cars," or "while passing over or under or standing upon buffers," were 41 killed and 643 injured. Suppose that automatic couplers would save 30 of these lives and 500 of these injuries. Estimating the 30 lives at $3,000 each, they represent a total of $90,000, which would leave $320 for each person injured. The real question is then: Is it worth $3,000 to save a man's life, or $320 to prevent the average injury received in coupling cars? Looked at from a purely economic point of view, we think the expenditure would be justifiable. Certainly when it comes to matters of signalling, English railways spend far more than $3,000 for each life saved by their very perfect systems of blocking and interlocking.

But we do not believe this is the whole of the economic question. Our English contemporary says in so many words that all the railway companies would receive in return would be the money they would otherwise pay for the deaths and injuries of employees incurred in coupling cars. We contend that the gain by changing to a system of coupling which would reduce slack between cars and economize in the time and labor of the yardmen would be worth all it would cost. Do the British railways always intend to haul freight in trains controlled by "brake-vans" loaded with pig iron? Have they nothing to learn from the revolution which has been wrought in the movement of freight on American railways through the adoption of larger cars and long and heavy trains? Already British manufacturers and miners are complaining that the cost of hauling freight is one cause for their defeat in export trade by Germany and the United States. We believe that it is quite time English railways began to consider some better coupling than the old hook and chain, and it is manifest that to change to any other than an automatic coupling at the present day would be absurd.

LETTERS TO THE EDITOR.

Determining the True Meridian.

Sir: A slight error in printing occurs in the letter on "Determining the Meridian by Observations on the Sun with a Transit," in your issue of May 20. In the computation under "Average Vertical Angle, the 31° 01' 20" should read 'True Altitude,' not "Declination." As regards the editor's note on the effect of the sun's parallax; the sun's horizontal parallax being about 8.6", the effect upon the altitudes observed will always be less than 8.6", and for observations taken at the best time of

day, say from 9 to 11 a. m., and 1 to 3 p. m., will generally be about one-half that amount, always too small to sensibly affect observations taken with a vertical circle reading only to 1' or 30".

Yours truly, A. W. French.

Hanover, N. H., June 5, 1897.

The True Depth of Water on Galveston Bar.

Sir: My attention was recently called to a misstatement in an article on the Galveston Harbor by Mr. W. J. Sherman in your issue of March 18, referring to the water on the bar. In looking up the matter I find that the article contains this statement: "Unofficially the writer learns that there is now about twenty feet at mean low tide."

As this has been circulated to the effect that we only had twenty feet, I would ask that you publish the following statement on the depths at mean low tide as made by the monthly surveys under the direction of Maj. A. M. Miller, Corps of Engineers, U. S. A.:

	Feet.
September, 1895	20
October, 1895	20
November, 1895	20⅜
December, 1895	20⅜
January, 1896	21
February, 1896	22
March, 1896	22¼
May, 1896	22¼
June, 1896	22
July, 1896	23⅜
August, 1896	24¼
September, 1896	24⅜
November, 1896	24⅜
December, 1896	25
January, 1897	25
February, 1897	25
April, 1897	25¼

Yours truly, C. F. W. Felt,

Chief Engineer Gulf, Colorado & Santa Fe Ry. Co.

Galveston, Tex., May 29, 1897.

The Attitude of the Board of Examiners of the New York Building Department Toward Fireproof Floor Constructions Other than Tile.

Sir: In your edition of May 13, page 296, you have an editorial which states that nothing but burnt clay can be used in New York for fireproofing, according to the New York Building Ordinance. As we are interested in a fireproof floor, we procured a New York Building Ordinance, which is dated Jan. 1, 1897. In this it says (p. 34) that walls of fireproof buildings may be built of brick, stone, iron or other hard incombustible materials, and that floors and roofs shall be of materials similar to the walls. On p. 37 it says: "The floor arches may be of sectional hollow brick or hard, burnt clay, porous terra cotta or some equally good fireproof material." Further, it says on this page: "The bottom flanges of all rolled steel floor beams may be covered with iron metal lath, properly secured and plastered on the under side." All these points, it seems to us, allow the use of other materials than burnt clay for fireproofing; for instance, concrete and plastered metal lath for ceilings.

Would you kindly enlighten us whether the Board of Examiners interprets the points which we quoted in a way that excludes all other materials but burnt clay from fireproofing? Yours respectfully, The S. K. Co.

Chicago, May 28, 1897.

(Our correspondent will find in Engineering News of Feb. 4, 1897, a full statement of the attitude of the New York Board of Examiners toward fireproof floor construction other than tile, and in our issue of May 27 he will find a statement by a member of the Board of Examiners further defining his position. We believe with our correspondent that according to a proper interpretation of the New York Building Law, it is as legal to use concrete for floor arches as it is to use tile, unless it can be shown that concrete is not "an equally good fireproof material." The volume of evidence which has now accumulated showing that concrete is as good as or better than tile as a fireproof material is something that the authorities sooner or later will have to recognize.—Ed.)

Standard Tests of Paving Blocks and Bricks at Philadelphia.

Sir: Having recently adopted a standard formula for testing paving blocks and bricks to be used in street paving under the Bureau of Highways of this city, I take pleasure in forwarding you a copy showing the results of our first tests of samples from the output of several of the principal factories.

The method is to take a sample of 15 blocks or bricks from any of the factories, carefully grade them from the lightest to the darkest, and consecutively number them from 1 to 15. From the lots thus arranged, we select the ten numbered 1, 3, 4, 6, 7, 9, 10, 12, 13 and 15 for the laboratory test, reserving the five numbered 2, 5, 8, 11 and 14 for office samples.

In this way, the 15 give a fair sample of the product of the factory, and those selected for the laboratory test, give a fair average of the samples submitted for testing.

The details of the formula, you will find in the blueprint herewith forwarded, which I thought might be of interest to you. The report includes only such samples as meet the standard requirements of the department, those rejected not having been included.

Very truly yours,

Thomas L. Hicks,

Chief of Bureau of Highways.

Philadelphia, May 24, 1897.

(The blue print states that the tests were made at the testing laboratory of Booth, Garrett & Blair, Philadelphia.—Ed.)

An Early Use of Electric Light in a Cement Quarry.

Sir: In the article in your issue of May 27, on "Electric Lighting of a Cement Quarry," it is stated that the Norton cement quarries are "believed to be the first instance in which electric lighting has been used in cement quarries in this country."

Allow me to say that this is a wrong impression, and that our Eastern friends are about 14 years behind the times, so far as electric lighting in cement mines is concerned. In the spring of 1883 the Utica Cement Mfg. Co. equipped their works, which are situated two miles west of Utica, Ill., with an electric light plant, consisting of a Vanderpoel dynamo and 12 arc lights, which were used for lighting the cement mines or quarries exclusively.

About six years ago this plant was replaced by a Mather incandescent dynamo, with a capacity of 200 16-c. p. 110-volt lamps. These are distributed through the yards and buildings at the works, as well as throughout the mines. In the mines the lamps are placed in the entries at a distance of 40 ft. apart, and suspended from props alongside the car tracks.

The rooms in which the men are at work are lighted by eight lamps placed on two boards, one on each side of the room, and connected with the main wires by means of reels, on which the wires are wound up and removed from the room while blasts are fired.

The entries and rooms are 40 ft. wide and separated by a pillar of 20 ft. The cement vein is from 12 to 14 ft. thick.

About two years ago the company opened up another cement vein, which is located about 40 ft. above the vein just mentioned, and opens on a level with the top of the kilns. The cement rock is taken direct from the mine to the kilns, without any rehandling or hoisting, thus saving a great amount of labor.

The mills of the Utica Cement Mfg. Co. have an annual capacity of half a million barrels of cement, and have in recent years been equipped with the latest and best machinery for manufacturing a high grade of natural cement. The company's testing room at the works is equipped with all the latest improved apparatus for cement testing, in charge of an expert of 20 years' experience in cement manufacturing, and no cement ever leaves the mills without being thoroughly tested before shipping.

Respectfully yours, A. Preuss, Supt.

Utica, La Salle Co., Ill., June 4, 1897.

COMPOUND LOCOMOTIVE FOR THE ROYAL BAVARIAN STATE RAILWAY.

The complacent indifference with which the engineers in charge of the motive power departments of European railways regard the multiplication of parts and complication in the details of their locomotives is always a matter of astonishment to American railway engineers. The most remarkable instance of this kind that has been brought to our notice in a long time is a compound locomotive built by Krauss & Co., of Munich, for the Royal Bavarian State Railway, which we find illustrated in the "Zeitschrift des Oesterrichischen Ingenieur-

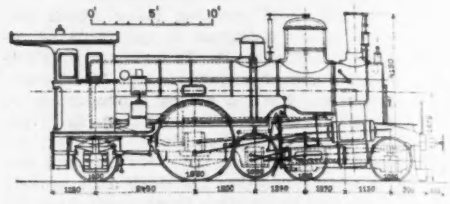


Fig. 1.—Compound Single Driver Locomotive with Auxiliary Driver for Starting.

Designed and Built by Krauss & Co., Munich, Germany, for the Bavarian State Ry.

und Architekturen-Vereines." The engine may be briefly described as a cross between a Johnstone compound, with its annular cylinders, as used on the Mexican Central (Eng. News, Aug. 29, '91.) and the Philadelphia & Reading single driver express locomotive. Grafted on this is an extra pair of drivers with cylinders, connecting rods, valve gear and other paraphernalia, whose sole purpose is to "give a lift" when the engine is starting a heavy train and its normal adhesion is insufficient.

We are so lacking in appreciation of designs of this sort in this country that in order to do justice to this machine we shall have to translate the description given in our contemporary.

The single-driver locomotive is handicapped by the fact that its tractive power is limited by the weight that may be placed on a single pair of driving wheels. On the other hand, the removal of the trailing axle from beneath the firebox permits the latter to be made deeper and more spacious and enables a large ashpan to be used. The latter especially is regarded as an important matter when long runs are to be made.

The last trial of speed between the London & Northwestern and Great Northern railways in England has demonstrated afresh the advantages of engines without coupling rods. There has, therefore, been no lack of effort to adapt the modern English, fast passenger locomotive to roads where an axle weight of 18 tons is sufficient. In the same category with these experiments we must place those undertaken during recent years by the Baldwin Locomotive Works of Philadelphia for the purpose of increasing the weight on the driving axle at the moment of starting, to say nothing of the steam sander which is an English device that is always found upon every single-driver engine in England. We must also include, in this same class, those experiments which were made on an American road in increasing the adhesion of the driving wheels by electro-magnetism.

The first experiments was a failure. The Baldwin test locomotive for the Philadelphia & Reading R. R. was built in 1893 and, regarding the electrical increase of adhesion,

Results of Standard Tests of Paving Blocks and Bricks at Philadelphia, Pa.

Samples and where made.	Material and color.	Description. Length, ins.	Width, ins.	Thickness, ins.	Area, top surface, sq. ins.	Volume, cu. ins.	Weight, lbs.	Specific gravity.	[1]Cross-breaking strength, lbs. per in. width.	[2]Crushing strength, lbs. per sq. in.	[3]Impact, per cent. loss, 30 min.	[3]Impact, per cent. loss, 60 min.	[4]Absorption, per cent. gain.	Rating. Cross breaking.	Crushing strength.	Impact test No. 1.	Impact test No. 2.	Absorption.	Total rating.
Blocks.																			
Metropolitan Block Co., Canton, O.	Shale; dark red.	10.74	3.94	3.50	37.60	148.10	9.91	2.46	5,720	16,520	5.35	6.40	.67	5.72	4.13	19.65	18.60	2.33	50.43
Mack Pav'g Co., N. Cumberland, W.Va.	Fire clay; yellow	9.00	4.00	3.125	28.13	112.50	9.04	2.49	6,246	9,930	7.08	6.07	2.29	6.25	2.48	17.92	18.93	.71	46.29
Bricks.																			
Canton Paver, Canton, O.	Shale; red.	10.38	4.00	2.50	25.95	103.80	7.14	2.44	4,940	17,810	7.89	10.29	1.22	4.94	4.45	17.11	14.71	1.78	42.99
Montello Clay & Brick Co., Reading, Pa.	Shale; chocolate.	8.75	4.125	2.375	20.80	85.80	6.97	2.40	4,573	12,413	8.95	8.02	1.22	4.57	3.10	16.05	16.98	1.78	42.48
Perkiomen Brick Co., Oakes, Pa.	Shale; red.	7.75	3.875	2.563	19.9	77.1	6.56	2.50	4,460	11,760	8.64	7.45	3.10	4.46	2.94	16.36	17.55	— .10	41.21
McAvoy Vit. Brick Co., Perkiomen Junctn.	Shale; red.	8.125	3.875	2.50	20.31	78.70	6.78	2.38	5,895	10,573	13.43	7.95	3.58	5.89	2.64	11.57	17.05	— .58	36.57
Francis & Rausch, Pine Grove, Pa.	Shale; dark red.	8.25	4.00	2.375	19.60	78.40	6.48	2.25	5,866	9,263	11.68	11.82	2.00	5.87	2.32	13.32	13.18	1.00	35.69
Clearfield Clay Wrkg Co., Clearfield, Pa.	Mixed red.	8.52	3.958	2.413	20.56	81.35	6.54	2.43	6,218	12,465	14.43	10.52	2.65	6.22	3.11	10.57	14.48	.35	34.73
Mack Paving Co., N. Cumberland, W.Va.	Fire clay; yellow	8.250	4.125	2.375	19.59	80.80	6.42	2.48	5,832	8,738	10.07	13.17	4.81	5.83	2.18	14.93	11.83	—1.81	32.96
Hamburg Vit. Brick Co., Hamburg, Pa.	Shale; dark red.	8.875	4.125	2.50	22.19	91.52	7.22	2.48	5,715	8,985	12.42	12.94	2.92	5.72	2.25	12.58	12.06	.08	32.69

[1] Cross-breaking strength.—Center load between supports 6 ins. apart.
[2] Crushing Strength.—Specimen on edge; as laid in paving; top and bottom surfaces ground parallel.
[3] Impact.—In a 24-in. rattler, making 30 revs. per min.
[4] Absorption.—First dried 24 hours at 212° F.; then immersed 24 hours in distilled water.

nothing but reports without any authentication whatever, have come to us from the other side of the Atlantic.*

In the solution of this problem, Krauss & Co. have started out with the assumption that at the moment of starting, the single-driver locomotive must be given an increased adhesion and an increased drawbar pull; that an increase of steam production at this time would be superfluous, since the starting is effected in a few seconds, so that the increase in steam consumption is a matter of no importance. The construction being the same, there should also be an increase of adhesion on steep grades, while an increase of drawbar pull is of less importance in the scale, since the time-table is always so arranged that the speed is

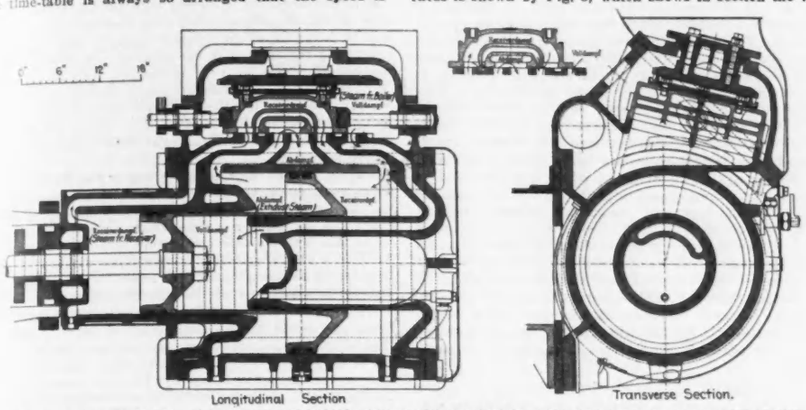


FIG. 2.—LONGITUDINAL AND CROSS SECTIONS THROUGH CYLINDER AND STEAM CHEST OF COMPOUND LOCOMOTIVE.

less upon such stretches, so that the adaption of boiler and cylinders in the modern, express-passenger locomotive is perfectly adapted to the limits of adhesion. The construction under consideration oversteps these limits on grades since the increase of the blast increases the production of steam per unit of heating surface.

These conditions are fulfilled by the introduction of supplementary cylinders, valve motion, connecting rods and driving axle with a mechanism for throwing the same in and out of gear. Apparently, advantage of this apparatus is worth what it costs when we consider that this working mechanism is quite small. The cylinder is only 11.42 ins. in diameter, with a stroke, of 18.11 in.; the wheel is only 39⅜ ins. in diameter, and the cost of the whole apparatus will not be any more than that of a driving wheel of 6 ft. 1¼ in. diameter with its side rod, to say nothing of the complication involved in the construction, the arrangement of the springs and the ash pan. Furthermore the operation of this small helper costs very little since it is in service only for a few seconds at a time with long intervals of idleness between. Hence it will require less lubrication and will also be less expensive to maintain than the large wheels of the main engine.

This locomotive, with the auxiliary axle, is in all other particulars exactly like the fast passenger locomotives of the Royal Bavarian State Railway, in conjunction with which it is worked. In its construction due regard was paid to the possibility of rebuilding it into a standard engine of this same type, with a somewhat lengthened wheel base. Another feature of these engines that may be mentioned, is the arrangement of the two front rows of crown-sheet stays whereby a considerable amount of expansion is permitted to the tube-sheet without subjecting the crown-sheet of the firebox to an excessive amount of bending. Prominent among the boiler fittings are a short brick arch in the firebox, which has gradually been receiving a more and more extended application in Austria, and the water separator in the dome, which has been carefully worked out, and into which a special dry pipe opens.

The chief feature of the locomotive is the assumption of a coefficient of adhesion of 1 in 4.5, which is quite within bounds, since it will always be possible to supplement any lack of adhesion by the operation of the supplementary axle. The helping engine would naturally be made small and would also be designed with a view of lessening the supply of spare parts, such as tires, piston rings, etc., which would be otherwise provided for the second-class engines of the Bavarian railways.

The valve motion of the main engine is of the Heusinger von Waldegg type, to which is coupled a Stephenson gear for the secondary engine, so that the driver has but one reversing screw to operate. This connection of the two gears is arranged, as it is in the Prussian compound locomotives, so that, on account of the different lengths of the hangers, the point of cut-off of the main and auxiliary cylinders changes differently; as, for example, while the cut-off in the main engine rises from 30% to 85%, that of the auxiliary cylinders rises from 20% to 80.5%.

The starting mechanism of the compound engine is of the new Lindner type, with exhaust passages in the high-pressure valve. The arrangement of the auxiliary apparatus is shown by Fig. 3, which shows in section the vertical steam cylinder. Upon starting from a standstill, the auxiliary driving wheels are brought into service by opening a small steam admission pipe, which gradually raises the pressure in the vertical cylinder.

In order to put the auxiliary axle into service while running, as at the foot of a grade, the first thing to be done is to bring the axle into play by opening a small cock; then, when the weight is down upon the rails, full pressure of steam is admitted to the cylinder.

This necessitates that the three steam pipes should be so connected with each other that the driver must always follow the method of manipulation that has just been described. This interlocking, as it may be called, appears desirable when we consider the great number of revolutions that will be made by the small machine, but the actual manipulation does not differ in any respect from that to which we have been accustomed for a number of years, and which is operated without any delay whatever in throwing the rack gear into service in the mixed (rack and adhesion) Abt locomotives.

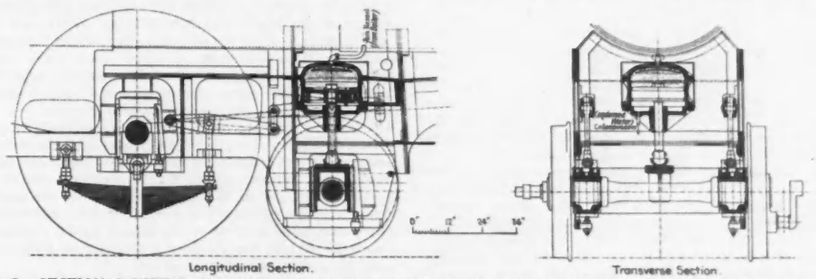


FIG. 3.—SECTIONAL VIEWS SHOWING APPARATUS FOR LOWERING AND RAISING AUXILIARY DRIVING AXLE.

The following is a table of the axle loads in tons, with the auxiliary axle both in and out of service:

Trailing Axle.	Auxiliary Axle.	Driving Axle.	Leading Axle.
24.0	....	14.0	14.0[1]
15.2	14.0	14.0	8.8[2]

[1]Without auxiliary; [2]with auxiliary.

This distribution of the weight is made possible by the spring connection between the driving and the auxiliary axles, whereby when the auxiliary axle is brought into service the locomotive will be raised about 0.8-in. on the spring.

The locomotive manufacturers have, in accordance with their general custom, made a careful analysis in detail of the hauling capacity of this locomotive and have shown that in the eight fast express trains running out of Munich with the normal loading of about 190 tons that is given to the fast trains of Bavaria, there are, in all, about six points at which the auxiliary axle would have to be brought into action on the run. In actual service, without counting the slowing down for signals and other unexpected delays, the application of the auxiliary axle would be still more infrequent, since, on the Oriental express, for example, with its normal load of 124 tons, there are many points that could be passed without the use of the auxiliary axle.

*For the benefit of our contemporary we may explain even at this late day that the increase of adhesion by electro-magnetic action was to the best of our knowledge and belief an unmitigated humbug. The scheme worked beautifully—on the exhibition model—for the reason that the little incline on which the model was exhibited was of metal, and the magnetic fields of the motor which draws the little car, of course, exerted a considerable pull, which amounted to increasing the pressure of the wheels upon the rail considerably above that due to gravity alone. By this means the model car was able to climb grades of extraordinary steepness; but the success of the scheme ended right there.—Ed. Eng. News.

THE USE OF HIGH STEAM PRESSURES IN NON-COMPOUND LOCOMOTIVES.*

By Dugald Drummond, M. Inst. C. E.†

This investigation was instituted to ascertain what increase of efficiency or economy is derived from raising the boiler pressure in non-compound locomotives, and whether high initial piston-pressures are prejudicial to the mechanism of this type of engine, working under the severe conditions imposed by modern express traffic. The tests took place on the Caledonian Railway, between Carlisle and Edinburgh, one of the heaviest pieces of main line in Great Britain.

The engines selected for this purpose were Nos. 76, 77, 78, 79, built at the railway companies locomotive works, St. Rollox, Glasgow, and put in service in the latter half of 1889. Nos. 76 and 79 have each a working pressure of 200 lbs., No. 77 a working pressure of 175 lbs., and No. 78 a working pressure of 150 lbs. per sq. in. They are of the bogie type, with cylinders 18 × 26 ins., and are identical in every respect, except boiler pressure.

The trains selected for experiment were the 4.30 p. m., from Carlisle (from London), and the 10.15 a. m., from Edinburgh (to London), express. These trains were timed to run at a down mean speed of 51.35 miles an hour; and at an up mean speed of 50.08 miles an hour between terminal stations; the 50 miles between Carlisle and the summit of Beattock incline, with a vertical rise of 947 ft., having a time allowance of one hour.

Thus the conditions under which the trials took place were of a nature to bring out the respective merits of the engines working under the different boiler-pressures.

Tests.

The method of procedure adopted was to take indicator-diagrams of the four engines at the same points on the up and down journeys, with, however, some variations in the case of engine No. 76. Upwards of 20 indicator diagrams, right and left, with simultaneous dynamometer readings, were taken each way. Twelve of these have been selected for the purposes of this investigation. The regulator handle had a graduated scale attached, to show the amount of opening of the regulator steam valve. The smoke-box temperature was taken with a Murrie mercurial pyrometer; the position selected for its insertion being at the side, level with the top row of tubes, 9 ins. in front of the tube plate and 3 ins. clear of the back edge of the exhaust nozzle. The steam chest was fitted with a Bourdon pressure gage and a thermometer. The cylinders were also fitted with thermometers. These had to be inserted with pipes, and led above the front foot-plate to facilitate reading. The bulbs were also immersed in a mercury bath, with an iron casing to ensure a safe joint under the high steam pressures.

The smoke-box temperature was taken before starting, and immediately after arriving at the terminal station, as well as at the points where the engines were indicated. The results obtained point to the advantage of working with early cut-offs. They also show that improved boiler circulation is required to give more rapid generating power in producing steam. The difference between the temperatures of the steam chest and cylinder is given, the thermometers registering under identical conditions of distance and protection from radiation. But the steam-chest thermometer, on account of the comparatively constant pressure, had a small escape pipe, with a cock placed at the upper end to allow fresh steam to circulate round the bulb. The cylinder thermometer did not require this, as fresh steam was sent to the bulb at every stroke. The results obtained show that the mean cylinder temperature is not the mean of the initial and exhaust temperatures due to their pressures, as has been assumed. This assumption ignores what is evident in these and similar diagrams of non-compound engines, namely, that the steam

*From Selected Papers of the Institution of Civil Engineers; vol. cxxvii., 1896-97; Part 1.

†Locomotive Superintendent, Caledonian Railway.

cycle begins at the boiler pressure, and terminates, not at the exhaust pressure, but at the pressure due to the compression. The indicator diagrams show that the final temperature of the compressed steam is in nearly all cases equal to or above the boiler temperature.

The design of the cylinders is a departure from the normal arrangement with a central valve face. The steam ports were moved to the cylinder ends, and the slide valve was divided, each having its own exhaust port. In this way the port clearance was reduced to a minimum, and a reduction in back pressure was effected. The weight of the valve, however, was increased by 70%. The exhaust passages were increased so that the belt from the lower and top valves extended along the whole length of the cylinder, thus forming an exhaust steam jacketed cylinder. The blast pipe, which was of the vortex type, had likewise a large exhaust capacity with a nozzle equal to a 5-in. opening.

The weight of the engines for all purposes was taken as the mean between their running weight before starting and after arrival at the terminal station. The speeds were taken by stop-watch observations between mile posts and also by counting the engine reciprocations from the indicator; and it was found that the latter was the more reliable method, as eye, ear, and touch could be brought into requisition.

The indicator used was of the Tabor form, a type which the author recommends for high-speed engines. Where diagrams on one side are wanting, the power given out by each cylinder has been assumed to be equal. The horse power absorbed by the blast pipe resistance, and the compression, as well as that expended in overcoming the train resistance, and termed "effective," are each computed. The sum of the three is termed the "total horse power." The ratio of each of these to the total horse power has also been calculated.

The train resistance was recorded by the dynamometer, consisting of two cylinders fitted with rams and charged with oil. The pull of the drawbar was transmitted through the crosshead and rams to the fluid, which communicated with a pressure gage on the foot plate. The readings of the gage were taken by an attendant. It worked satisfactorily and was capable of measuring pulls from zero, no initial pressure on the gage being necessary. The gage readings taken when indicating, were afterwards converted into the equivalent force in pounds. This was done by transferring the dynamometer and connections to a Pooley weighing machine, where a series of weighings with ascending and descending pressures were taken. By this means the uncertain element of ram-friction was eliminated. The total resistance of the engine and train combined was computed from the effective horse power. The engine resistance given is the difference between the total and that indicated by the dynamometer.

The measurements to determine the weight of steam used were taken at 3 ins. from the point of cut-off for the steam received. For the steam retained, the measurements were all taken at one-tenth from the end of the stroke during the period of compression. For the weight of steam in percentages at each point of indication, those above zero are in favor of the higher pressures; those below zero are in favor of the lower pressures in the engines compared. The water used was measured in the tender by means of a graduated rod, which was inserted in a glass tube. The quantities given include the loss from the injector and the steam escape pipe of the steam chest thermometer, and are therefore approximate.

The coal used was of very inferior quality, as may be seen from its evaporative efficiency; 50% of that used would have passed through a ⅜-in. mesh riddle. To test the persistently low evaporation, the small coal put on the tender of No. 79 for the down run was passed through a riddle of ½-in. mesh, and the fine discarded; the evaporation then rose to 6.94 lbs. of water, but again declined again on the following day for the up run, when 40% of unriddled coal was added to what had been left on the down run. The evaporation fell to 6.2 lbs. of water per lb. of coal, showing that with the unriddled coal supplied to the other engines the evaporation would have been less than 6 lbs. The author has no hesitation in saying that 25% passed into the atmosphere without evaporating 1 lb. of water per lb. of coal. The coal consumption of the four engines has been compared in terms of an evaporation of 8 lbs. of water per lb. of coal, that being the mean evaporative power of fresh coal supplied to the Caledonian Railway. The coal used in these three experiments had mostly been stacked over twelve months. This was due to the collieries being closed consequent on a miners' strike at the time the experiments were begun. An analysis of the comparative coal consumption of the different engines cannot be give for want of the requisite details, which embrace the determination of the total work and the comparative rate at which it is done by each engine on the up and down grades for every revolution during the entire journey. This can only be obtained accurately from a continuous series of indicator diagrams. A continuous dynamometer record is not sufficient, as it gives the work done on the train only. Taken in conjunction the two records would determine the most economical engine.

Reciprocating Parts of the Engine.

These include the piston, piston-rod, crosshead, slide blocks and connecting rod. In the engines under consideration, they weigh 830 lbs., or 3.26 lbs. per sq. in. of the front, and 3.5 lbs. per sq. in. of the back of the piston. It is in terms of the cylinder area only that the reciprocating parts have been considered; and their modifying effect on the piston pressures transmitted to the cranks were constructed for each engine.

This is a subject of paramount interest and importance to engineers, for the high piston speeds in locomotives are attained with short strokes, and consequently with a high rate of revolution. It is especially interesting at the present time, when increased locomotive efficiency is sought in compounding, and when engines on that principle are run at high speeds. The diagrams showed that the driving stresses were transmitted to the cranks throughout a complete revolution, with an entire absence of shock. The reversal of pressure on the cranks was accomplished gradually during the terminating stroke, at a point where the tangential pressure nearly vanished; so that all the elements requisite to the maintenance of high speeds over long distances were secured. That high initial steam pressures are indispensable for high piston speeds with short strokes, has long been known; and it is clear from the investigation that a steam pressure of 200 lbs. per sq. in. on the piston of an 18-in. cylinder, is by no means the maximum limit from a dynamic point of view. The non-compound engine has always sufficient steam pressure to start and accelerate its reciprocating parts, at speeds above those attained in modern express traffic; with sufficient compression to gradually reverse the pressures on the cranks for the incoming steam of the following stroke. With separate steam and exhaust valves to secure a reduction of pressure, and a longer steam admission to the back than to the front of the cylinder, the driving cycle of this type of engine can be made perfect.

Economy of Higher Steam Pressures.

The method adopted to determine the comparative efficiency of the different pressures was to ascertain from the indicator diagrams the weight of steam used per horse power per hour, this being the best method admissible at present in an investigation of this kind. It would have been preferable to have taken a continuous sheet of indicator diagrams of every stroke from start to finish, as then the absolute work done by the engines would have been known, and would have been comparable; but the author does not know of any apparatus of this kind having been arranged for locomotives. The accompanying tabulated statements give the observations and results.

The economy obtained by increasing the boiler pressure, apart from compounding, has been established in traffic as well as in these investigations. Mr. S. Johnson, of the Midland Railway, by raising boiler pressures from 140 lbs. to 160 lbs. per sq. in., effected a saving of fuel of between 11 and 13%. Mr. J. Holden, of the Great Eastern Railway, has verified Mr. Johnson's results by the reverse process in the compound engine, in lowering the boiler pressure from 160 lbs. to 140 lbs. per sq. in. The former saving of 12% of fuel then dropped to 2%; and if the low-pressure cylinder of this engine had been 25½ ins. in diameter instead of 26 ins., so as to have the same cylinder capacity as the two non-compound cylinders they were tried against, the remaining 2% would have become negative. Both these results agree closely with the 15% of steam saved between the Caledonian Railway engines No. 77 (with a boiler pressure of 175 lbs. per sq. in.) and No. 78 (with a boiler pressure of 150 lbs. per sq. in.), the weight and speed of trains drawn by both engines being generally alike. Again, between engine No. 76, with a boiler pressure of 200 lbs. per sq. in., and engine No. 78, the saving effected amounts to 31%, even though the speed and weight of the train were in favor of the latter. Again, between engines No. 76 and No. 77 there is a saving of steam, effected by higher pressure, of 11.92%.

A consideration of the conditions under which the steam does its work in both engines, will not show any superiority for the compound over the non-compound engine. On this subject the phraseology of the marine engineer has been adopted and developed, although the working conditions of the marine and locomotive engine are widely different in two of the most important elements of economy, namely, quality of steam and piston speed. In the locomotive the steam reaches the cylinder through the highly heated atmosphere of the smoke-box, and must be in a very different condition from that finding its way into the high-pressure cylinder of the marine engine. This is manifest from the investigations of the Research Committee of the Institution of Mechanical Engineers.[1] It has sometimes been assumed that cylinder condensation and re-evaporation occur to a serious extent in non-compound inside-cylinder engines. But the steam absorbs heat from the smokebox in passing to the cylinders, and must reach them very dry, at a temperature above that of saturation. On entering the cylinder, the steam from the boiler mixes with compressed steam at or above the boiler temperature. The cylinders also form part of the smoke-box, and heat is conducted through the cylinder walls as well as being generated by the friction of the piston rings. When to these is added a piston speed of 1,000 ft. per minute, equal to train speed of 55 miles an hour, which gives a duration of one-fourth of a second for a revolution, the necessity for expanding steam in two cylinders to prevent condensation and re-evaporation, is greatly reduced. It is difficult to conceive how more favorable conditions for the transformation of heat energy can exist in a steam engine. The principal factor in preventing cylinder condensation and re-evaporation is high piston speed; a speed of 1,527 ft. per minute was reached during the trials with engine No. 76, at a train speed of 81.8 miles per hour.

Modern express traffic therefore offers a guarantee that condensation and re-evaporation in inside cylinder non-compound locomotives must be an infinitesimal quantity, and this is verified by the high mean cylinder temperature and the weight of steam used per horse power per hour—the latter comparing favorably with the best marine practice in triple-expansion condensing engines. The advantage of reduction of the thermal range in each cylinder of compound locomotives is not apparent; since the steam is maintained twice as long in contact with the cylinder surfaces, and the surfaces are nearly trebled in area. Although the high pressure cylinder exhaust absorbs heat in passing through the receiver, it is difficult to see how a high thermal efficiency can exist under these disadvantageous conditions.

During part of the running of engine No. 76 five expansions were made, the efficiency increasing to the highest point. As the whole question of engine economy resolves itself into the number of times steam can be expanded, and as in this case five expansions were within the economical limit in a single cylinder, compounding within this limit appears to be unnecessary. If, however, the thermal and dynamical conditions of the non-compound are superior to those of the compound engine, how is it that those who favor the latter system have attained superior results? The reply must be that the two systems have not been compared on a fair basis. In the first place, the boiler pressure of the compound locomotive has been usually higher. In the second, place, the driver of the compound engine is obliged to keep up the boiler pressure, as there must be considerably less range of mean cylinder pressure than in the non-compound engine, which can expand steam as low as 1¼ times, and all starting from stations is so done, whereas the compound locomotive cannot expand less than 2½ times. This reduction of range in the power of the latter engine is undoubtedly the cause of reduced coal consumption over what is due to higher boiler pressure. Other things being equal, coal consumption is the measure of the work done by an engine, and if the compound engine cannot run so fast in express traffic, or has to be assisted on up grades, the result should not be credited to increased efficiency. The author is of opinion that in a comparative trial of the simple and compound systems, the boiler pressures should be alike. The minimum number of expansions should be alike; and the low pressure

[1] Proceedings of the Institution of Mechanical Engineers, 1889, p. 235.

Table No. 1.—Coal Consumption at Different Pressures.

Engine. No.	Wght.	Boiler pressure per sq. in., lbs.	Mean coal consumption per mile, lbs.	Mean water evaporated per lb. of coal, lbs.	Mean coal consumption evaporating 8 lbs. of water per lb. of coal, lbs.
76.....	78	200	45.91	5.934	34.053
77.....	77	175	44.42	5.907	32.798
78.....	76	150	53.22	5.661	37.650
79.....	77	200	42.27	6.576	34.749

Table No. 2.—Observations from a comparative Set of Indicator Diagrams.

Engine, No.	76	77	78	79
Speed, miles per hour.....	48.25	47.32	49.18	51.04
Steam pressure, boiler.....	200	170	155	200
" " steam chest	200	170	155	200
Opening of throttle.....	¾	Full	⅝	Full
Mean cut-off, per cent.....	21	27	33	26
Revolutions per minute.....	208	204	212	220
Mean pressures; indicator diagrams				
Effective, lbs. per sq. in..	52.18	48.50	52.96	53.50
Back, lbs. per sq. in.....	7.50	8.50	11.60	6.10
Compression, lbs. per sq. in.	15.12	11.70	8.06	15.90
Initial driv. press. on piston.				
Front, lbs. per sq. in.....	190.0	152.0	137.5	181.0
Back, lbs. per sq. in.....	190.0	150.0	139.0	190.5
Initial press. trans to cranks.				
Front, lbs. per sq. in.....	129.4	93.8	74.6	113.3
Back, lbs. per sq. in.....	145.5	116.2	92.9	140.8
Press. per sq. in. of piston area required to start recip. parts f'm rest at dead center.				
Front	60.6	58.20	52.9	67.7
Back	44.5	42.75	46.1	49.7
HP., effective	715.24	652.00	739.95	775.56
" blast pipe	102.80	114.26	163.24	88.79
" compression	207.24	157.96	182.45	226.01
" total	1,025.28	924.22	1,085.64	1,090.36
Per cent. of total HP., effective	69.76	70.54	68.16	71.12
Per cent. of total HP., blast pipe	10.02	12.36	15.04	8.14
Per cent. of total HP., compression.....	20.21	17.09	16.80	20.72
Tractive resistance, lbs. per ton.				
Engine	23.23	22.53	59.95	15.21
Train (from dynamometer)	49.93	56.22	25.24	74.18
Total	36.32	37.43	41.17	41.28
Steam used per rev., lbs.	1.055730	1.084104	1.297053	1.060640
Steam used per HP. per hr., lbs.				
Total	12.85	14.35	15.19	12.84
Effective	18.42	20.35	22.29	18.05

cylinder of the compound engine should be equal to the combined areas of the non-compound cylinders. On this common basis only should the trials be conducted, and no analysis offers greater advantages than the one adopted here. Such a test should be made with engines on the compound principle against non-compound engines, say for a month's duration, in order that their respective merits may be tested in a way that will settle doubts existing on the question.

Viewing the question of steam pressures broadly, the author has come to the conclusion that for the present, until enginemen appreciate the value of and take advantage of higher pressures for ordinary locomotive engines working main line traffic economically in all respects, the pressure should not be less than 150 lbs. nor more than 170 lbs. per sq. in. Pressures of 200 lbs. per sq. in. can, he believes, only be economically used with engines working heavy suburban passenger traffic, whereby speed can be got up quickly when leaving stations. By this means a larger amount of traffic can be worked in a given time than by engines with pressures of 140 lbs. per sq. in., which is the average now used in working such trains.

Table No. 1, condensed from the appendices to Mr. Drummond's paper, shows the results of two trips (in opposite directions) of 101.1 miles each. The engines weighed about 76 to 78 gross tons (including tenders). The southbound trains weighed 137 to 153 tons, and the northbound trains 217 to 246 tons, inclusive of engine and tender. The speed of the southbound trains was from 49.147 to 53.861 miles per hour; and that of the northbound trains from 43.679 to 59.678 miles per hour. Table No. 2 is a compilation of the results observed from one set of indicator diagrams.

PROFILES OF TRANSCONTINENTAL RAILWAYS.

(With double-page engraving.)

The profiles of transcontinental railway lines which we publish on our inset sheet this week show at a glance the comparative features of the several lines reaching the Pacific Coast. There is in the United States no one transcontinental railway, that is to say, one single line crossing the continent from the Atlantic to the Pacific, but the term is very generally applied to the main lines crossing the Rocky Mountains and connecting the great eastern and central railway systems with points on the Pacific coast. Of these lines there are seven, as follows: (1) Great Northern Ry., from St. Paul, Minn., to Everett, Wash.; (2) Northern Pacific R. R., from Chicago, Ill., St. Paul, Minn., and Duluth, Minn., to Tacoma, Wash.; (3) Union Pacific Ry. and Oregon Railway & Navigation Co.'s line, from Omaha, Neb., to Portland, Ore.; (4) Union Pacific Ry. and Central Pacific R. R., from Omaha, Neb., to San Francisco, Cal.; (5) Atchison, Topeka & Santa Fe Ry., from Chicago, Ill., to National City, Cal.; (6) Southern Pacific Ry., from New Orleans, La., to San Francisco, Cal.; (7) The Denver & Rio Grande R. R. (with its extension, the Rio Grande Western R. R.), forms an alternate route to No. 4, connecting with a branch from the Union Pacific Ry., at Denver, Colo., and with the Central Pacific R. R. at Ogden, Utah.

The only actual transcontinental railway is the Canadian Pacific Ry., which has its own line from St. John, N. B. (on the Atlantic coast), and Montreal and Quebec (on the St. Lawrence), to Vancouver, B. C. This is also the only line running regular through transcontinental passenger trains, all the other routes involving at least one change of cars.

Table No. 1 gives the terminal points and the maximum elevations of these eight lines, and also of the Southern Pacific Ry. line, running north and south along the Pacific coast from San Francisco, Cal., to Portland, Ore., which thus effects a connection between two of the principal transcontinental lines. The highest elevation obtained by any of these lines is 10,433 ft., where the Denver & Rio Grande R. R. crosses the continental divide at Tennessee Pass, near Leadville, Colo. Next to this comes the Union Pacific Ry., with an elevation of 8,247 ft. at Sherman, Wyo. The Atchison, Topeka & Santa Fe Ry. reaches an elevation of 7,623 ft. at Raton, N. M., while the Central Pacific Ry. reaches an elevation of 7,017 ft. at Summit, Cal. The Northern Pacific R. R. comes next, with 5,550 ft. at Blossburg, Mont., then the Canadian Pacific Ry., with 5,288 ft. at Stephen, B. C.; the Great Northern Ry., with 5,202 ft. at Summit, Mont., and the Southern Pacific Ry., with 5,082 ft. at Paisano, Tex. This latter has the lowest summit elevation of any of the lines.

TABLE 1. Transcontinental Railways.

Railway.	From	Elevation, ft.	To	Elevation, ft.	Distance, miles.	Point of max. elevat'n	Max. elev., ft.
Canadian Pacific	Montreal	65	Vancouver	10	2,904.8	Stephen	5,288
Great Northern	St. Paul	702.6	Everett	21	1,782.5	Summit	5,202
Northern Pacific	St. Paul	703	Tacoma	10	1,909.0	Blossburg	5,550
Northern Pacific	Chicago	588	Tacoma	10	2,370.6	Blossburg	5,550
U. Pac. & Ore. Ry. & Nav. Co.	Omaha	1,031	Portland	35	1,821.6	Sherman	8,247
Union Pac. and Central Pac.	Omaha	1,031	San Francisco	14	1,905.0	Summit	7,017
Atch., Top. & Santa Fe	Chicago	593	National City	10	2,394.0	Raton	7,623
Southern Pacific	New Orleans	11	San Francisco	14	2,496.0	Paisano	5,082
Den. & Rio Grande	Denver.	5,198	Grand Junction	4,594	455.9	Nr. Leadville	10,433
Southern Pacific	San Francisco	14	Portland	54	771.0	Siskiyou	4,125

It is the way in which the summits are reached, however, and not the actual elevation attained which is of interest from an engineering and operating point of view. Thus, for instance, the Southern Pacific Ry. has maximum grades of 1% at its highest summit elevation, but at the Tehachapi summit the maximum grades are 2.2%, and the heavy grades on this latter summit form one of the reasons for the construction of the company's new coast line from San Francisco to Los Angeles, which will have maximum grades of only 1%. Table No. 2 shows the elevations and grades on five of the lines above mentioned, from which it will be seen that the Atchison, Topeka & Santa Fe Ry. has an approximate total ascent of 34,003 ft. for westbound trains, the Canadian Pacific Ry., 23,051 ft.; the Northern Pacific Ry., 17,137 ft.; the Union Pacific Ry. (and O. Ry. & Nav. Co. line), 16,439, and the Great Northern Ry. only 15,305 ft. These figures indicate a very considerable difference in the operating advantages of the lines. Thus the total of the Atchison, Topeka & Santa Fe Ry. is the result of a very broken profile, many parts of which have steep and unfavorable grades, the maximum grades being 175 and 185 ft. per mile. On the other hand, the Great Northern Ry., with less than half the total elevation of the A., T. & S. F. Ry., has a much more even profile, with comparatively easy grades and maximum grades of 105 ft. per mile.

In this connection it may be of interest to refer to the elevations attained by some eastern trunk lines:

The Boston & Albany R. R. has a length of 202 miles, with an elevation of 10 ft. at Boston and 20.25 ft. at Albany. Its highest elevation is 1,453 ft., near Washington, Mass., 139 miles from Boston.

The Pennsylvania Division of the Pennsylvania R. R. has a length of 354 miles from Philadelphia to Pittsburg, with an elevation of 54 ft. at Broad St. station, Philadelphia, and 738 ft. at Pittsburg. The highest elevation attained is 2,154 ft. at Gallitzin, 250 miles from Philadelphia, at the crossing of the Alleghanies. The grades are as steep as 1.75%.

The Baltimore & Ohio R. R. has a length of 378 miles from Baltimore to Wheeling, with an elevation of 30 ft. at Baltimore and 645½ ft. at Wheeling. The highest elevations attained are 2,620 ft. at Wilson's Summit, 221 miles from Baltimore, and 2,550 ft. at Cranberry Summit, 19 miles beyond. This stretch of 19 miles is across the summit of the Alleghanies.

We come now to a consideration of the several transcontinental lines, but it must be remembered that the profiles are necessarily condensed and do not show each and every change of grade, so that a comparison in detail is not practicable. The accompanying map shows clearly the positions of the lines of which the profiles are given.

The Canadian Pacific Ry. has one of the best and most favorable lines, since its location is such as to reach the mountain region at a very narrow part, so that it has but two high summits to cross. It is true that it has actually heavier grades than any of the other lines, namely, some miles of 4½% west of the summit at Stephen, but on the other hand, these grades are short, and all the heaviest grades are bunched, so that trains can be economically handled by using helper engines on the divisions having these grades. The ascent from the prairies up the eastern slope of the mountains is made by generally easy grades. It is possible, too, that the new Crow's Nest Pass line through the southern part of British Columbia may open up a new and easier line through to the Pacific slope. At the eastern end the line has a broken profile from Sudbury, Ont., to Port Arthur, beyond which latter point it rises to a high plateau, but here again there are some unfavorable features in crossing the singularly rugged and broken country between Port Arthur and Winnipeg. Nevertheless, the steepest grades between Montreal and Winnipeg are but 1%. The Canadian Pacific Ry. was described in our issues of Nov. 28, 1895, and Jan. 14, 1897.

The Great Northern Ry. has a longer stretch of line through the mountains, but it gets through with an easier profile than that of the Canadian Pacific Ry. The main range of the Rocky Mountains is crossed by maximum grades of 1% on the west and 2% on the east, and the cabinet range is crossed by grades of 1.5%, while all these grades are concentrated in a way favorable to operating

MAP SHOWING TRANSCONTINENTAL RAILWAYS.

conditions. The maximum grades on the entire line are 2.2%, at the crossing of the Cascade range, west of the Columbia River. On the eastern portion of the line the maximum grades are 0.6%, as against the 1% grades of the Canadian Pacific Ry.

The Northern Pacific Ry. is less favorably located than either of the first two lines. For about 666 miles from St. Paul its maximum grades are 1%, the same as the Canadian Pacific Ry., and then there are 341 miles with grades of only 0.48%, which are easier than those of either of the other lines. In crossing the Belt Range, the Rocky Mountains and the Cascade Range, however, the maximum grades are 2.2%, and there is a much greater mileage of these grades than on the Great Northern Ry. It is to be noted, on the other hand, that these grades are so arranged that the regular trains can be economically operated by the use of helper engines or specially powerful train engines. On this line the summit of the most western range (the Cascades) is only about 80 miles from the western terminus of the line. The maximum grades between St. Paul and Chicago (on the Wisconsin Central R. R.) are 1.2%, but for the greater part of the distance the maximum is but 1%.

The Union Pacific Ry. has a steady ascent from the Missouri River, at Omaha, Neb., to the summit of the Rocky Mountains at Sherman (8,247 ft.), followed by a somewhat uneven, but not unfavorable, profile to Granger, Wyo. From this point there are two routes to the Pacific slope. The first of these, which is shown on the same profile as that of the Union Pacific Ry., is over the Oregon Short Line and Oregon Railway & Navigation Co.'s line to Portland, Ore. The second (shown by a separate profile), continues over the Union Pacific Ry. from Granger to Ogden and thence over the Central Pacific Ry. to San Francisco. On the first of these two routes the Oregon Short Line has almost a continuous descent from Granger to Huntington, but the O. R. & N. line has some heavy work in crossing the Blue Mountains, between Huntington and Umatilla. In general, the maximum grades on this route are higher than those of the northern lines, and these grades are more continuous, though there are 147 miles, between Reverse and Huntington, with maximum grades of only 0.48. Between Huntington and Pendleton, where three summits are crossed, the maximum grades are 2.2%. Beyond Granger the main line continues to Ogden, where it connects with the Central Pacific R. R. (as shown by the profile of the latter road). After leaving Granger it has a somewhat irregular profile, as it has to cross the Wahsatch range and then descend into the basin or valley of the Great Salt Lake.

The Central Pacific R. R. (now a part of the Southern Pacific Ry. system), formed, with the Union Pacific Ry., the first transcontinental railway, and a description of this line will be found in our issue of Nov. 5, 1896. Commencing at Ogden it climbs out of the basin of the Great Salt Lake and crosses the Humboldt range, beyond which it has a fairly regular profile until the ascent of the Sierra Nevada is commenced. After attaining the summit (7,017 ft. above the sea), the line descends the Pacific slope by long steep grades, with numerous curves. The descent continues for 106 miles to Sacramento, which is only 30 ft. above sea level. This gives an average grade of 1.23%.

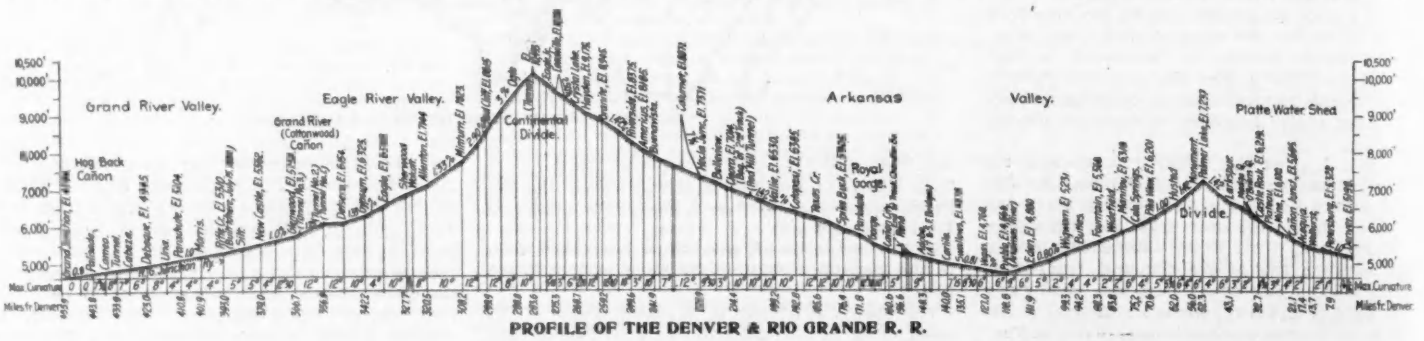
The Atchison, Topeka & Santa Fe Ry. has a profile which is unfavorable to operating conditions, being the most difficult of any of the lines, as will be seen by comparing the profiles. The line from Chicago to Kansas City keeps its grades pretty low, although even here there are grades of 58 and 79 ft. per mile, but beyond that it rises steadily to the Raton summit. Then comes a broken stretch to the Glorietta summit, followed by a long descent and a long rise to the summit of the Continental Divide, with another long descent and a steep rise to the summit of the Arizona Divide. Beyond this again comes a long broken descent and then an irregular profile, which includes the Piute and Cajon summits. Even beyond San Bernardino, which is well down on the Pacific slope, the line has to surmount grades of 116 ft. per mile before reaching the terminal port of National City, Cal., which is a few miles beyond San Diego.

The Southern Pacific Ry. has an easy line from New Orleans to San Antonio, and though it ascends to a considerable elevation between there and El Paso, its maximum grades are kept down to 1%, which grade, however, is very frequently used. The highest point reached here is Paisano, Tex., 5,082 ft., but on either side are Altuda, 4,642 ft., and Aragon, 4,899 ft. Beyond El Paso the profile is more broken, and grades of 1.4% are encountered at Railroad Pass and Dragoon summit, in Arizona. Then the line has an almost unbroken descent into the Salton basin and Dead Valley, where (at Salton) it reaches 265.4 ft. below sea level. Rising by grades of 2% to Beaumont, it has a broken profile, with grades of 1 to 2.2%, by which latter grades it passes Vincent and the Tehachapi summit, but after descending the western slope of the Tehachapi Pass, there are easy grades through the San Joaquin Valley to the coast. It has already been pointed out that the railway is building a new coast line from San Francisco to Los Angeles, having maximum grades of 1%, by which the steep grade line of the Tehachapi Pass will be avoided. The enormous twelve-wheel engines used on this latter line, with particulars of their performance, were described in our issue of May 9, 1895.

The Denver & Rio Grande R. R. has a very regular profile. Starting from Denver, with an elevation of 5,198 ft., it ascends to the summit at Palmer Lake (7,237 ft.) by grades of 1% to 1.42%, in 52 miles. Then there is a descent of 66.3 miles by grades of 1.42, 1 and 0.8% at Pueblo (4,668 ft.), followed by a rise on similar grades for 165 miles to an elevation of 10,433 ft., in the Tennessee Pass, on the summit of the Continental Divide. There is then a steady descent of 172.3 miles to Grand Junction (4,594 ft.). The grades on this are 3% and 2.9% for about 20 miles, followed by grades of 1.33, 1.25, 1 and 0.8%. On the steepest grades there are curves of 10° and 12°. The short branch from Hecla to Calumet is to be noted, as it has a grade of 7%, and is operated by ordinary adhesion

TABLE 2.—ELEVATIONS AND GRADES OF FIVE TRANSCONTINENTAL RAILWAYS.

From	Elevation, ft.	To	Elevation, ft.	Distance, miles.	Maximum grade.—West, ft. pr mile.	Maximum grade.—East, ft. pr mile.	Total ascent (Approximate.)—West, ft.	Total ascent (Approximate.)—East, ft.
		Canadian Pacific Ry.						
Montreal	65	Winnipeg	733	1,423.6	53	53	10,787	10,119
Winnipeg	733	Medicine Hat	2,147	660.3	53	53	4,060	2,946
Medicine Hat	2,147	Donald	2,540	362.3	116	237	4,173	3,780
Donald	2,540	Revelstoke	1,453	79.9	116	116	1,938	3,025
Revelstoke	1,453	Kamloops	1,160	128.2	116	116	1,173	1,466
Kamloops	1,160	Vancouver	10	250.5	53	53	920	2,070
Montreal	.....	Vancouver	.....	2,904.8	116	237	23,051	23,106
		Great Northern Ry.						
St. Paul	702.6	Williston	1,859	651.9	32	32	2,064.4	1,294
Williston	1,859	Pacific Junction	2,517	313.1	21	21	2,015	1,061
Pacific Junction	2,517	Kalispell	2,946	260.9	53	105	4,457	4,028
Kalispell	2,946	Spokane	1,869	251.3	79	79	2,340	3,417
Spokane	1,869	Everett	21	305.3	116	116	4,429	6,277
St. Paul	.....	Everett	.....	1,782.5	116	116	15,305.4	15,987
		Northern Pacific Ry. (and Wisconsin Central).						
Chicago	588	Waukesha	823	97.7	53	53	971	736
Waukesha	823	Steven's Point	1,093	151.4	53	53	1,623	1,353
Steven's Point	1,093	Abbotsford	1,427	53.8	53	41	778	444
Abbotsford	1,427	Chippewa Falls	829	54.3	58	63	638	1,236
Chippewa Falls	829	St. Paul	703	104.4	64	61	1,644	1,770
Chicago	.....	St. Paul	.....	461.6	64	63	5,654	5,539
St. Paul	703	Glendive	2,069	666	53	53	5,459	4,093
Glendive	2,069	Livingston	4,487	341	26	26	2,668	250
Livingston	4,487	Helena	3,932	123	116	116	1,714	2,269
Helena	3,932	Jocko	2,509	169	116	116	2,451	3,874
Jocko	2,509	Ellensburg	1,513	485	53	53	3,459	4,455
Ellensburg	1,513	Tacoma	10	125	116	116	1,386	2,889
St. Paul	.....	Tacoma	.....	1,909	116	116	17,137	17,830
		Union Pacific Ry. and Oregon Ry. & Nav. Co.'s Line.						
Omaha	1,031	Cheyenne	6,050	516.3	66	40	5,312	293
Cheyenne	6,050	Laramie	7,149	56.6	80	91	2,197	1,098
Laramie	7,149	Granger	6,279	302.6	66	63	2,302	3,172
Granger	6,279	Ticeska	3,087	357.9	66	79	1,306	4,498
Ticeska	3,087	Reverse	3,084	36.1	106	90	552	555
Reverse	3,084	Huntington	2,112	147.3	26	26	184	1,156
Huntington	2,112	Pendleton Junction	1,101	173.0	116	105	3,736	4,747
Pendleton Junction	1,101	Portland	35	231.8	74	90	850	1,916
Omaha	.....	Portland	.....	1,821.6	116	105	16,439	17,435
		Atchison, Topeka & Santa Fe Ry.						
Chicago	593	Kansas City	750	458	58	79	4,111	3,954
Kansas City	750	La Junta	4,061	571	63	61	5,197	1,886
La Junta	4,061	Albuquerque	4,950	348	185	175	8,440	7,551
Albuquerque	4,950	Winslow	4,838	285	53	53	2,930	3,032
Winslow	4,848	The Needles	477	290	75	137	5,307	9,678
The Needles	477	San Bernardino	1,075	250	87	158	6,163	5,565
San Bernardino	1,075	National City	10	192	116	116	1,855	2,920
Chicago	.....	National City	.....	2,394	185	175	34,003	34,586
Kansas City	.....	National City	.....	1,936	185	175	29,892	30,632



PROFILE OF THE DENVER & RIO GRANDE R. R.

locomotives. The Rio Grande Western Ry., which forms the extension of the line from Grand Junction to Ogden, crosses the Wahsatch range at an elevation of 7,465 ft., and descends into the Jordan Valley by a long, steep grade having numerous curves, as described in our issue of Oct. 15, 1896.

The Southern Pacific Ry. line, from San Francisco to Portland, 771 miles, has fairly easy grades for 300 miles. It then crosses the Black Butte summit by grades of 2.2%, and the Siskiyou range by grades of 3.3%. Beyond this the line has a broken profile, with long grades of 1% and shorter grades of 2.2%.

ELECTRIC MOTORS AT THE SACRAMENTO SHOPS OF THE SOUTHERN PACIFIC RY.

The completion of the long-distance transmission line betweeen Folsom and Sacramento, Cal., has led the Southern Pacific Ry. to apply electric motors for certain work at its shops at Sacramento, Cal., and the results thus far are said to have been very satisfactory, and to have shown an economy over the steam plant.

Three motors are used. The shop transfer table is driven by a direct-current motor of the street railway type, which uses a 500-volt current from the power station. It is so geared that it operates not only the table, but also drives a drum carrying a wire cable used to haul the locomotives upon the table. Instead of taking the current from the overhead wire by means of a trolley, the conductors are laid in an underground conduit and the contact is made by means of a plow running in this conduit. Some fears were at first expressed as to the result in rainy weather, but although considerable rain has fallen since the installation of this motor, no difficulty has been experienced.

The motor used to operate the machinery in the boiler shop, as well as in the tender shop, is a 50-HP. motor driven by a 440-volt alternating current from the step-down transformers. The machinery includes punching and shearing machines, which have heavy flywheels. For three or four minutes the motor has an excessive amount of work thrown upon it in starting the machine and until the maximum speed is acquired. The load then drops to 30-HP. The motor carries this heavy load without trouble.

The machinery in the spring shop is driven by a 10-HP. motor, which also has to cope with sudden heavy loads.

These two shop motors are of the General Electric Co.'s three-phase induction type, without commutator, collecting rings or brushes. They are driven by 440-volt three-phase alternating current from the transformers which step down the 11,000-volt current transmitted 24 miles from the generating station at Folsom.

SPECIFICATIONS AND GUARANTEE FOR CAST-IRON CAR WHEELS.*

Your committee appointed to revise the Specifications and Guarantee for Cast-Iron Wheels, and to consider the form of wheel, recommend for adoption the following specifications for cast-iron wheels:

(1) Chills must have the same inside profile as shown by M. C. B. drawing of the wheel tread. The inside diameter must be M. C. B. standard 33½ ins., measured at a point 2⅝ ins. from outside of wheel for 33-in. wheels, and 30⅝ ins. for 30-in. wheels, measured at the same point. The chills must be of equal diameter, and the same chill must not vary at different points more than 1-32-in. in diameter.

(2) Wheels of the same nominal diameter must not vary more than ¼-in. above or below the mean size measured on the circumference, and the same wheel must not vary more than 1-16 in. in diameter. The body of the wheel must be smooth and free from slag, shrinkage or blow holes. The tread must be free from deep and irregular wrinkles, slag, chill cracks and sweat or beads in throat, and swollen rims.

(3) The wheels broken must show clean gray iron in the plates, except at chaplets, where mottling to not more than ½-in. from same will be permitted. The depth of pure white iron must not exceed 1 in., nor be less than ½ in. in the middle of the tread, and shall not be less than ¼-in. in the throat. The depth of the white iron shall not vary more than ¼ in. around the tread on the rail line in the same wheel.

(4) For each 100 wheels which pass inspection and are ready for shipment, one representative wheel shall be taken at random and subjected to the following test:

The wheel shall be placed flange downward on an anvil block, weighing not less than 1,700 lbs., set on rubble masonry at least 2 ft. deep, and having three supports not more than 5 ins. wide for the wheel to rest upon. It shall be struck centrally on the hub by a weight of 140 lbs. falling from a height of 12 ft. Should this wheel stand five blows without breaking into two or more pieces, the hundred wheels shall be accepted. The above tests shall apply to standard weight wheels from 26 to 42 ins. in diameter, used on the standard gage roads.

Or, the wheel shall be placed flange downward on a cast-iron ring weighing 1,000 lbs., the outside diameter of the ring being 36½ ins., the inside diameter 24 ins., and thickness 8 ins., supported on rubble masonry at least 2 ft. deep. It shall be struck on the plate, close to the rim, by a weight of 100 lbs., falling from a height of 7 ft. When subjected to this test a 550-lb. wheel shall stand 20 blows; a 575-lb. wheel, 25 blows, and a 600-lb. wheel, 30 blows without breaking a piece out. This test applies to 33-in. wheels; 26, 28 and 30-in. wheels must stand the 25-blow test, and 36 and 42-in. wheels must stand the 30-blow test.

Or, the wheel must be laid flange downward in the sand, and a channel way 1½ ins. wide and 4 ins. deep, must be molded with green sand around the wheel. The clean tread of the wheel must form one side of this channel way, and the clean flange must form as much of the bottom as its width will cover. The channel way must then be filled to the top with molten cast iron, which must be hot enough when poured, so that the ring which is formed, when the metal is cold, shall be solid or free from wrinkles or layers. The time when the pouring ceases must be noted, and two minutes later an examination of the wheel must be made. If the wheel is found broken in pieces, or if any crack in the plate extends through the tread in either of the wheels tested, the 100 wheels represented by the test will be rejected.

(5) In either case of the drop tests, should the test wheel break in two or more pieces with less than the required number of blows, then a second wheel shall be taken from the same lot and similarly tested. If the second wheel stands the test, it shall be optional with the inspector whether he shall test a third wheel or not; if he does not do so, or if he does and the third wheel stands the test, the 100 wheels shall be accepted.

(6) Wheels shall not vary from the specified weight more than 2%.

(7) The thickness of the flange shall be regulated by the maximum and minimum flange thickness gages adopted by the M. C. B. Association and shown in M. C. B. Drawing No. 12.

(8) All wheels shall be numbered consecutively, and shall have the number, also the day, month and year when made, plainly formed on the inside plate in casting, and no two wheels shall have the same number. All wheels shall also have the name of the maker and place of manufacture plainly formed on the plates in casting.

(9) Individual wheels will not be accepted which (1) Do not conform to standard design and measurements; (2) Are under or over weight; (3) Have physical defects described in Section 2. Any lot of 100 wheels submitted to test will not be accepted: (1) If wheels broken do not meet the prescribed strength test; (2) If the conditions prescribed in Section 3 are not complied with.

It will be observed that no radical change in the specifications is recommended. Section 1 is made somewhat more definite and the variation allowed in the diameter of the same chill is reduced from 1-16 to 1-32 of in. Section 2 is modified by the addition of the words "swollen rims." Section 3 is modified by increasing the maximum allowable depth of white iron on the tread from ⅞ to 1 in., and increasing the minimum in the throat from 3-16 to ⅛ in. It is believed that these changes are desirable and can be readily complied with. Section 4 is changed by adding the thermal test, which consists in heating the tread of the wheel with molten metal. It is universally conceded that in almost all cases of wheels broken in pieces the cause is rapid heating of the rim from application of the brakes, and the proposed test reproduces such circumstances more perfectly than any other tests which have been suggested. The only question with reference to this test is whether the test as proposed is not so severe that in order to meet it the wheelmakers may be compelled to use materials which will seriously impair the durability of the wheel. The testimony on the subject, however, is of such a character as to induce your committee to recommend this test. Section 9 is a new section and is simply called for to complete the proper applications of the specification.

Your committee is of the opinion that the guarantee adopted in 1893 has never been put in practical operation, and is inclined to think that in some of its requirements it is impractical. After securing proper strength, which is effected by the general specifications, the most important consideration to a railroad company is that of mileage. Our specifications are quite full on the matter of strength, but strength to a great extent varies inversely as durability. Setting aside cases of breakage arising from allowing wheels to run until the flange is worn too thin or the tread too much worn, the breakage of wheels seems to be caused almost exclusively by rapid expansion of the rim due to severe application of the brakes. From this point of view the strength of the wheel is increased: (1) By the use of soft tough iron; (2) By doctoring mixture with ferro-manganese; (3) By reducing the amount of scrap; (4) By softening the mixture and thus reducing the depth of white or chilled iron on the tread; (5) By methods of manufacture. The durability of the wheel is increased: (1) By the use of hard, brittle irons; (2) By avoiding the use of ferro-manganese; (3) By reducing the amount of scrap; (4) By hardening the mixture and thus increasing the depth of white or chilled iron in the tread; (5) By methods of manufacture.

It will be seen from the above that items 1, 2 and 4, which tend to increase the strength of the wheel, are diametrically opposite to items 1, 2 and 4, which go to increase the durability of the wheel. It is a difficult matter for railroad officials to go into the minute details of wheel manufacture. A test for strength is of service, but is not sufficient to determine the actual value of wheels when that value depends so much upon the durability of the wheel, as well as its strength.

An ideal specification for wheels would be as follows: (1) The chill test must show the mixture chilling ⅞-in. deep. (2) The chill on the tread of the wheel must be within 1-16-in. as deep as on the chill test, and must be uniform in depth around the tread. (3) The chill in the throat must be within 1-16-in. as deep as on the tread. (4) Wheels of the same nominal diameter must not vary more than ⅛-in. above or below the mean size measured on the circumference. (5) Wheels must be perfectly cylindrical. (6) The tread of the wheel must be perfectly smooth and free from wrinkles, sweat or defects of any kind. (7) The body of the wheel must be free from any defects incident to general foundry work. (8) Wheels must stand a strength test as specified.

A glance at our present specifications shows how far short of these conditions the average wheel falls. It can be stated as a fact that the mileage of the best average wheels is nearly twice as great as the average of the poorer wheels. This is most important for railroad officials to consider. They are not in position to watch the details of manufacture or the materials used, or to determine by an inspection of a few wheels how much wheel service they lose by wheels falling short of the best that can be done in material, strength, chill, etc. If now railroad officials should purchase mileage instead of wheels they would get just what they pay for, and if one wheelmaker should furnish one hundred thousand miles of wheel mileage for less money than another, there would be no uncertainty in the contract, as there is when wheels are bought for, say, $5, when $6 wheels may furnish $10 worth of mileage as compared with the $5 wheels. This problem might be practically solved by a contract.

The report continues with a formal contract suggested as meeting the conditions of the preceding paragraph, but as a number of its terms would vary under different conditions, and as it gives little information in addition to what has already been given or to what will follow it is omitted. The report then continues as follows:

With reference to the present guarantee on freight car wheels, of four or five years' minimum service, it is generally recognized by close observers that this is a guarantee which does not guarantee. The average service of a fair ordinary chilled wheel is between seven and eight years, and in many cases this average is increased to 12 or 14 years. The futility of a four or five-year guarantee can be readily seen from the above.

In the matter of weight of wheels, your committee has received various recommendations showing a wide range of opinion as to what is the proper weight. For instance, for 60,000-lb. cars the recommendations run from 540 lbs. to 700 lbs. It is the opinion of your committee that with fair material a 580-lb. wheel is perfectly safe for 60,000-lb. cars, and in view of the fact that the lighter cars are rapidly disappearing, it is recommended that wheels less than 550 lbs. should not be cast.

The accompanying tables show the number of blows required to break a piece out of the wheel, the drop weighing 100 lbs. and falling 7 ft., the test having been made on one lot of wheels denominated "light pattern," which weighed 554 lbs., the other test being made on a lot of wheels denominated "heavy pattern," which weighed 580 lbs. It will be seen that the average number of blows necessary to break a piece out of the light, or 550-lb. pattern, was 58; with the 580-lb. pattern the number of blows required to break a piece out was 91. This shows

Table Showing Comparative Number of Blows from a 100-lb. Weight Falling 7 ft. Close to Rim Required to Break 580-lb. and 554-lb. Cast-Iron Car Wheels:

Heavy Pattern, 580-lb. Wheels.

		Defects.
No. of blows	63	Breakdown.
" " "	64	Sand wash.
" " "	160	Swelled flange.
" " "	153	Breakdown.
" " "	152	Breakdown.
" " "	102	Swelled flange.
" " "	84	Breakdown.
" " "	99	"
" " "	44	"
" " "	67	"
" " "	56	"
" " "	35	Light plate.
" " "	64	Breakdown.
" " "	84	Swelled rim.
" " "	42	Breakdown.
" " "	200	Breakdown.
Average blows	91½	

Light Pattern, 554-lb. Wheels.

		Defects.
No. of blows	91	Light plate.
" " "	36	Light plate.
" " "	22	Breakdown.
" " "	78	Breakdown.
" " "	46	Swelled rim.
" " "	65	Breakdown.
" " "	47	Light flange.
" " "	85	Breakdown.
Average blows	58⅝	

*Report of a committee of the Master Car Builders' Association presented at the Annual Convention held at Old Point Comfort, Va., June 8, 1897, by J. N. Barr, Sup. Motive Power, C., M. & St. P. Ry.; S. P. Bush, Sup. Motive Power, Pennsylvania Lines West of Pittsburg; John Hodge, Master Car Builder, Atch., Top. & S. Fe Ry.; J. H. McConnell, Sup. of Motive Power, Union Pacific Ry., and William McWood, Sup. Car Department, Grand Trunk Ry.